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This fifth and final report describes activities since June, 1965. Centralization of the Eisenhower Library Collection was completed early in 1965 and a circulation system became operational in April, 1965. The main portion of this report focuses on various aspects of the circulation system such as preparation of identification cards; the photographic process; circulation control operations (date due stickers, key punching and verifying, library utilization, work in process delay, quality control, and computer operations); and a simulated borrowing study. It is proposed in the report that an all-numeric code replace the call number or input identifier in the circulation system. The processing and updating procedures for the shelf list on tape are described. Acquisitions, cataloging, and activities of the library staff are discussed briefly. (CC)

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FINAL REPORT (NO. 5)

ON

AN OPERATIONS RESEARCH

AND

SYSTEMS ENGINEERING STUDY

(NSF GRANT GN-31)

DECEMBER 1968

Microfiche

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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(National Science Foundation Grant NSF-GN-31)

THE MILTON S. EISENHOWER LIBRARY

THE JOHNS HOPKINS UNIVERSITY

BALTIMORE, MD., 21218

DECEMBER 1968

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SECTION I

RECAPITULATION AND

SUMMARY

RECAPITULATION AND SUMMARY

Beginning approximately on July 1, 1961 and for six years thereafter, the National Science Foundation has provided support for studies of the Milton S. Eisenhower Library of The Johns Hopkins University. During the fiscal year July 1, 1967 - June 30, 1968 these studies have been continued by the University without outside support, and continuance is planned for fiscal 1968-69 as well, although it is hoped that further NSF support may be provided for additional research.

Progress of the research project previously has been published in four reports as follows:

No. 1, July 1962,

No. 2, April 1963,

No. 3, June 1964,

No. 4, June 1965.

The first of these Progress Reports presented organizational information about the Library and the research staff, outlined a preliminary cost model, described work sampling studies of staff performance, and proposed computer procedures for control of circulation.

The second Progress Report was devoted largely to discussion of proposed computer techniques for circulation control and for conversion of the shelf list to magnetic tape, a conversion now referred to by the acronym SLOT (Shelf List on Tape).

The third report, prepared by Dr. Benjamin F. Courtright, Research Associate, dealt with the SLOT procedure in an important new way. Earlier plans had envisioned the successive operations of preparing positive

prints of shelf list cards, editing, and keypunching the edited copy, followed by computer processing. These original plans were set aside pending an exploration of the possibility of machine reading the shelf list cards by multi-font character recognition. While this optical scanning capability was found to be infeasible, a single machine-readable format was found to offer attractive improvements and SLOT procedures were changed to a sequence of operations as follows:

1. Microfilming of shelf list cards,
2. Typing in a machine-readable font from microfilm reader images,
3. Conversion to magnetic tape by optical scanning.

This revised procedure eliminated editing but required formulation of decision rules for reduction of shelf list card entries to suitable length. Using this technique the SLOT operation was performed but much more has transpired since then with respect to this part of the project, and the more recent events will be reported below.

Progress Report No. 3 also described new procedures for computerized circulation control. Original plans had contemplated the use of a pre-punched card in the pocket of each book; at each charge-out this card and the borrower's identification card would be processed to provide input information to the computer. Discharges were to be processed in the same way, except that, for these, ID cards would not be required. This system design was changed to employ a photographic procedure which now has been operational for about three years. Problems related to this part of the project also will be reported in greater detail below.

The fourth, and most recent Progress Report, issued in June 1965, presented additional information and details about SLOT and the photo-

graphic system of circulation control, including for the latter photographs and print-outs of the several operations. In addition, Progress Report No. 4 described a study of acquisitions and cataloging which had led to a decision model for dealing with the chronic backlog which seems to characterize this part of library operations. This too will be further reported upon below.

All but the first of these Progress Reports have had wide circulation, to all members of the Association of Research Libraries and to various others who have requested information. This report will be circulated in the same way.

This report has been prepared jointly by Robert H. Roy, Principal Investigator, and Benjamin F. Courtright, Research Associate. However, as will become clear to the reader, those comments which concern Dr. Courtright's role in the venture could not gracefully be made by him; these have been written solely by the Principal Investigator.

The Johns Hopkins University
Baltimore, Maryland 21218
December, 1968

SECTION II

ACTIVITIES SINCE JUNE 1965

ACTIVITIES SINCE JUNE 1965

GENERAL COMMENTS

Most of the progress reported below will consist of a record of steps necessary for the implementation of concepts already reported, a process which has consumed three years and which is not yet altogether complete. There have been hardships and frustrations as well as accomplishments associated with this introductory period and it seems desirable to report misadventures as well as achievements, if only for the sake of other university libraries contemplating analogous innovations.

Relations with the staff of the Library have remained basically harmonious throughout the entire period and we have continuously enjoyed the support of the Librarian and the administration but there have been stresses and strains created as a consequence of the changes made. These, as will be shown, have imposed additional burdens upon the professional library staff, burdens of new and strange kinds. They have borne these burdens with fortitude and good nature but, not unnaturally, more than a little spleen has been vented upon the new system and that strange new device, the computer.

This observation requires restating in broader perspective. Professional librarians by need, tradition, and inclination have been bibliophiles, a word here intended to connote much more than it denotes. There has now -- at least in this Library -- been thrust into this bibliophilic world a strange new machine, mysterious, inexorable, and exacting, compelling librarians to think and behave in new ways, often contrary to their natural interests and inclinations. This has been a source of strain,

strain, one may venture to predict, that will be encountered by every library which ventures toward new technology.

A second observation may be stated as a kind of paradox. From the beginning the new system has had capabilities which did not exist under the former system of manual records. Borrowers unable to find a wanted item on the shelves could not go to a print-out of books in circulation, as they can now, and inquiry at the circulation desk often would fail to yield the sought-for information. Provision of this new service, however, at times has seemed to yield more discontent than satisfaction; an item not on the shelf and not on the print-out would bring accusations against the new system, accusations either of error or slowness in processing data. These charges often were justified but other possibilities (books lost or stolen, reshelved in the wrong location, internally borrowed, in an oversize range) were ignored and the new system became the focus of complaint.

Analogously, in earlier days borrowing privileges were more lax, again because of the special efforts needed for recall. The computer system provided a remedy for this by permitting systematic recall notices to borrowers, with fines if need be. Initial issuance of such notices was traumatic and again system errors were the focus of complaint, but the trauma was as much a social as a system phenomenon.

Having the shelf list on tape will permit print-outs by call letters, which will give bibliographic listings which are at least to some extent categorical. This too is a service not hitherto available but like the others just described it may fall short of perfection. Having been at least twice bitten, we no longer expect hosannahs for this new information but instead anticipate that it will generate a hunger for more and yet more than will at first be provided.

As an additional general comment, some problems of implementation have been confounded by external events. Installation of the new circulation control system followed hard upon centralization of the collection in the Eisenhower Library, a drastic change from the branch collections which had formerly been located in eight different buildings on the campus. While the decision to centralize had been given strong faculty and administration support, there were more than a few malcontents and some of their dissatisfactions rubbed off on the new system.

Similar confounding occurred with respect to the Identification Cards required by the new system. A few members of the faculty objected strongly to the cards as a kind of hated symbol of regimentation but surprisingly many wanted a university identification emblem that could be used more generally, at a hotel or bank, for example. This broader need brought an agonizing delay for dialogue on the subject.

A final general observation is most important. The burden of installation of the system has fallen upon a graduate student, a candidate for a Ph.D. in Operations Research and Industrial Engineering. Engineering is by definition applied and this has been an applied problem. But the tasks of implementing a complex change like this one, while they are assuredly instructive, are unsuited for such an academic goal. The individual in question, as his dissertation at long last has shown, has been scholarly, creative, imaginative, and devoted to the point of great self sacrifice but such tasks should not be thrust upon a degree candidate. This final general comment may serve both as a warning to others and an expression of profound thanks to the person whose travail is recounted below.

CIRCULATION CONTROL

Centralization of the collection in the Eisenhower Library was completed early in 1965 and the new system of circulation control, as stated in Progress Report No. 4, became operational in April of that year. For readers unfamiliar with the earlier report the system again is outlined and illustrated here.

Each person entitled to use the Library is provided with an Identification Card bearing his name and an assigned number (Figure 1). To charge-out one or more items, the borrower presents his ID card and the books at the Circulation Desk, where the ID card and call number labels are photographed in the position also shown in Figure 1. The camera, shown beneath the counter in Figure 2 and in close up in Figure 3 automatically advances after each exposure on a reel of 35 mm. film. The clerk at the Circulation Desk then places a due date sticker on each book (Figure 4) and turns them over to the borrower, who passes through the exit after showing the due date stickers to the guard stationed at the turnstile.

Each day, or more often if the volume of transactions is high, the film is developed for viewing in a microfilm reader (Figure 5) at which a keypunch operator transcribes the borrower's ID number, and the call numbers for each transaction. The film is then moved to another microfilm reader where each punched card is proofread for accuracy. The verified cards are then processed on the computer, where they are merged in call number order with books already on loan and printed out as the current list of books in circulation. (Figure 6).

Discharge procedure is similar: the borrower returns the books to the Circulation Desk where they are photographed as shown in Figure 2.

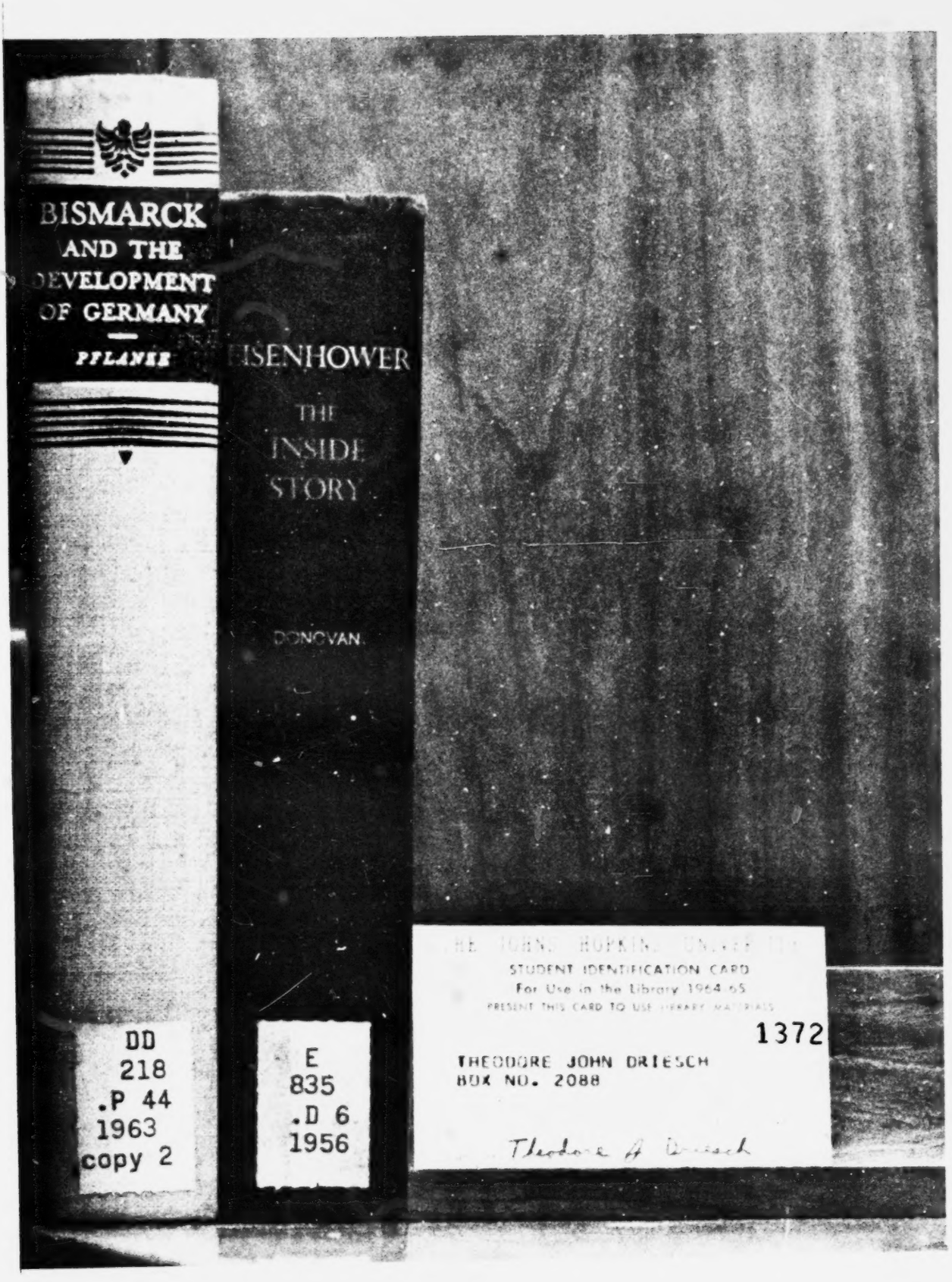

Fig. 1 Books and identification card positioned for charge-out

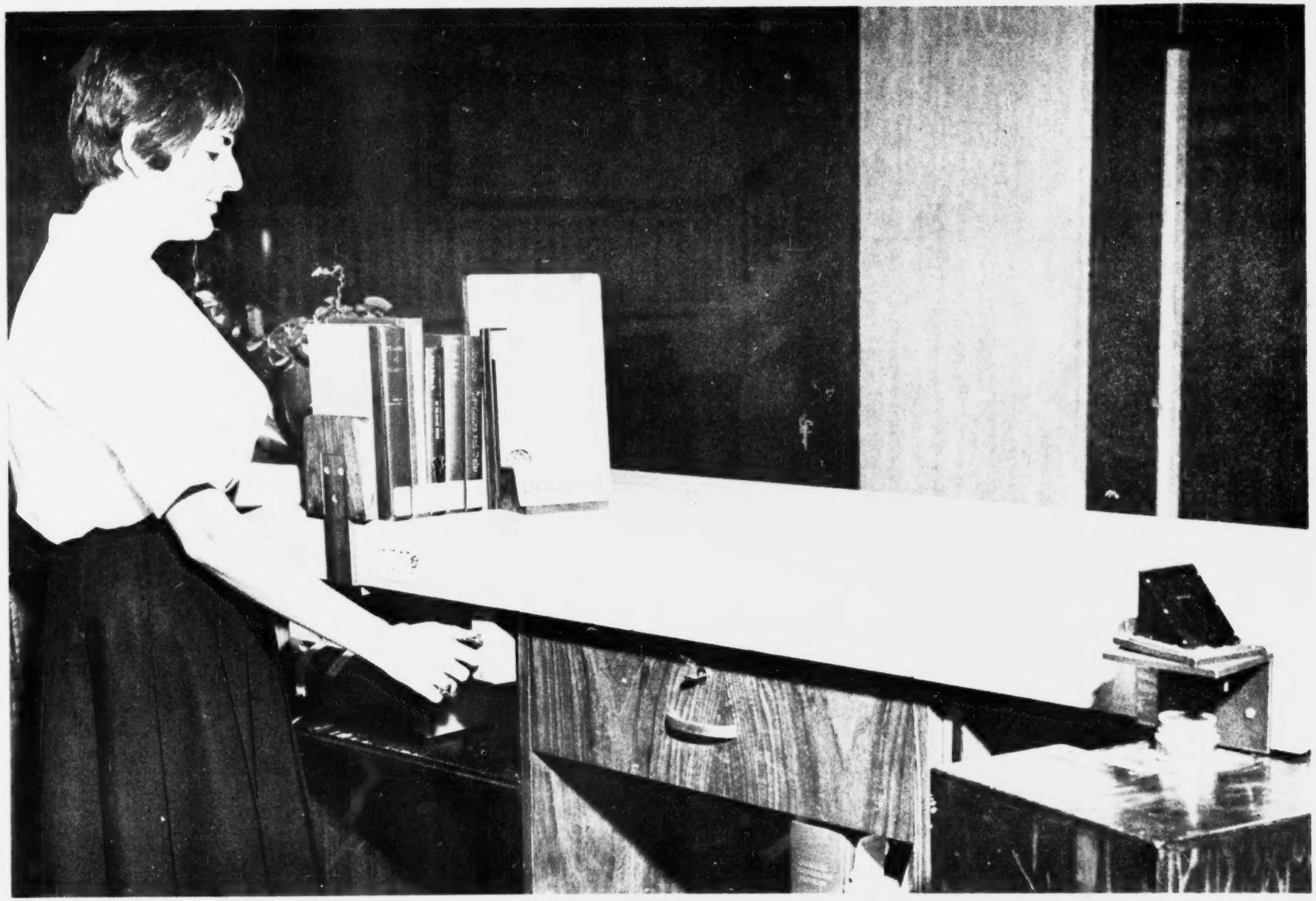

Fig. 2 Recording returned items for discharge

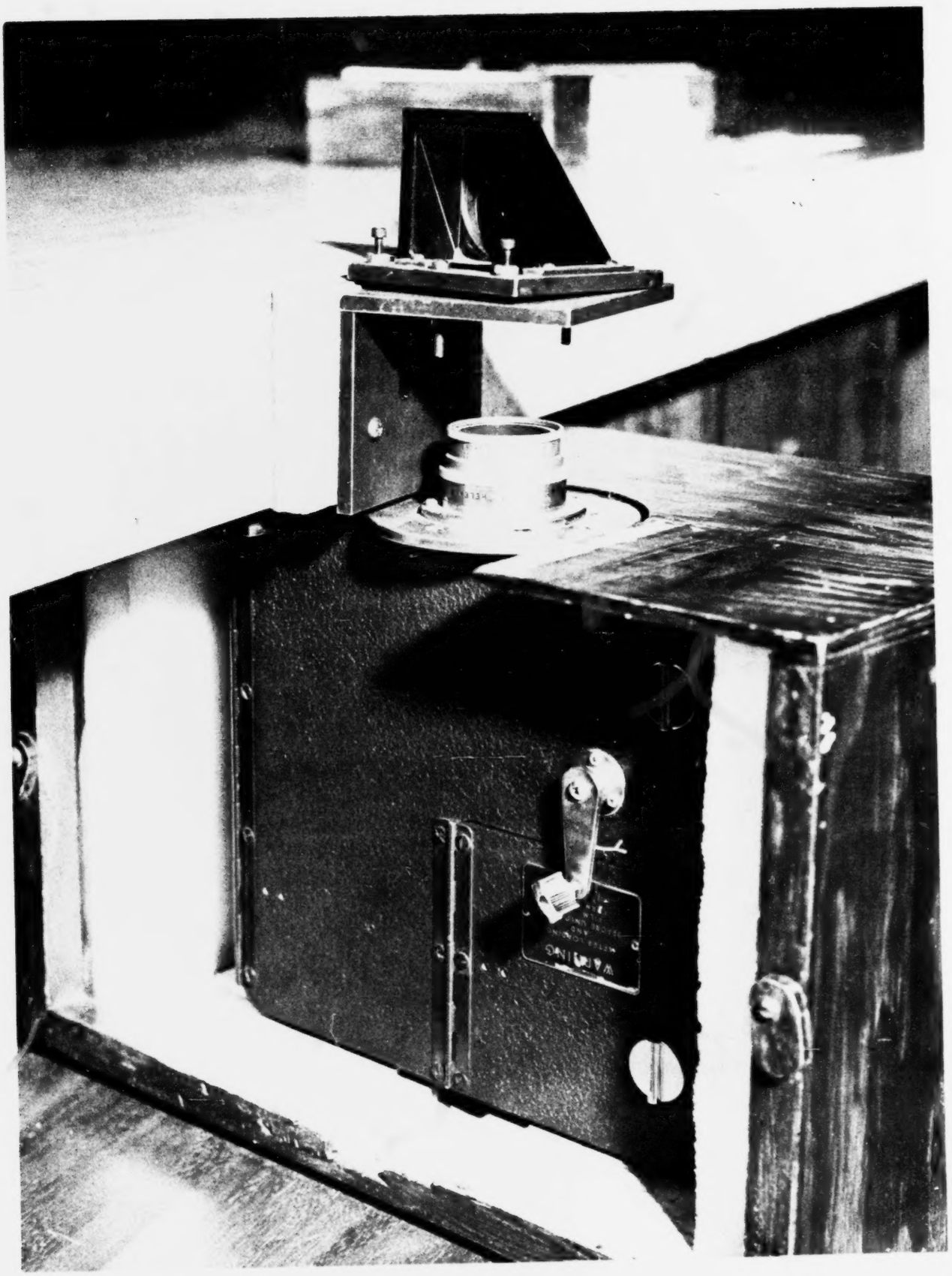

Fig. 3 Close-up of camera

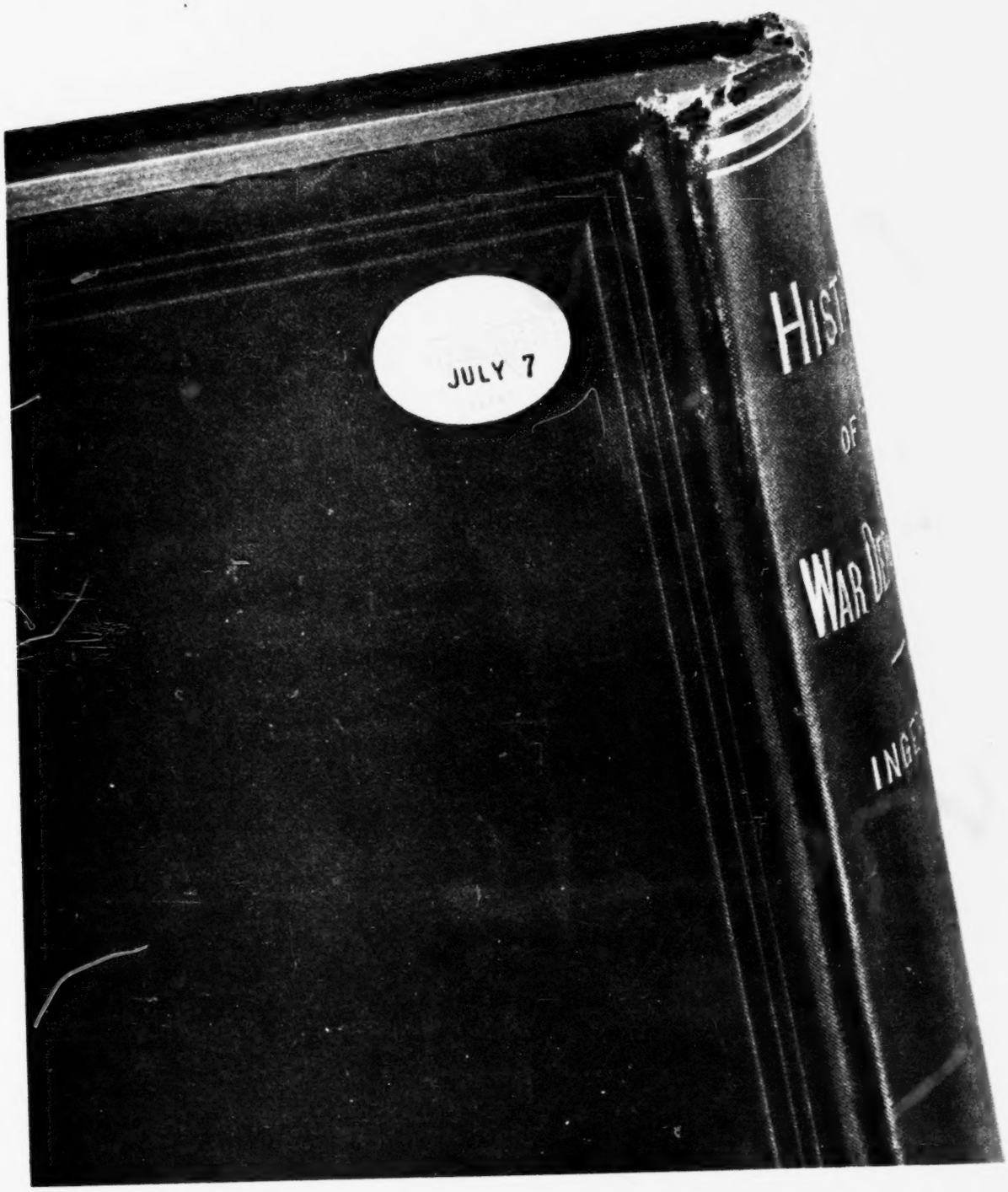

Fig. 4 Pressure-sensitive label with due date

Fig. 5 Microfilm reader and key-punch machine

05/14/68 THE JOHNS HOPKINS UNIVERSITY LIBRARY CIRCULATION LIST

	BORROWED	DUE	CALL NUMBER
2981	05/04/68	5/22	QP 475 .G7 1965
2981	04/15/68	5/15	QP 475 .P57 1967
0016	03/14/68		QP 475 .S72 1961
3595	05/02/68	5/22	QP 479 .G7 1963 PSYCH
2777	05/07/68	5/22	QP 479 .I5 1964
3595	04/23/68	5/22	QP 479 .W6 1966
3595	05/02/68	5/22	QP 481 .G4 1964 Q
2981	05/04/68	5/22	QP 481 .H453 1964
3595	05/02/68	5/22	QP 481 .R8 1962
15655	05/04/68	5/22	QP 514 .C32 1967
0035	02/05/68		QP 521 .I5 1966
1123	04/26/68	5/22	QP 521 .P8 1964 CHEM
0035	02/05/68		QP 551 .B8 1965
4170	04/24/68	5/22	QP 551 .C44 1966
0035	02/05/68		QP 551 .C5 1966
0035	02/05/68		QP 551 .I52 1967 V.1
0035	02/05/68		QP 551 .N45 1963 V.1 BIOL
0035	02/05/68		QP 551 .N45 1963 V.2 BIOL
0035	02/05/68		QP 551 .N45 1963 V.3 COPY3 BIOL
0035	02/05/68		QP 551 .N45 1963 V.4 COPY2 BIOL
0035	02/05/68		QP 551 .P47 1962 COPY2 BIOL
4105	05/03/68	5/22	QP 551 .P7 1965
3836	05/13/68	5/22	QP 551 .S938 1966 V.4
0035	02/05/68		QP 551 .W65 1963
2937	04/17/68	5/15	QP 601 .F4 1964
0828	12/03/67		QP 601 .V5 S4 1967 V.1
0562	05/06/68		QP 601 .W5 1966
0053	03/29/68		QP 701 .J4 1965 V.2 A
0053	03/29/68		QP 701 .J4 1965 V.2 B
0007	04/15/68		QP 751 .C4 1 1966-67
4709	03/28/68	5/1	QP 751 .I5 1962 BIOL
4105	05/06/68	5/22	QP 801 .A5 S9 1962 BIOL
0244	8/02/67		QP 801 .H7 I5 1962 V.1
0244	8/02/67		QP 801 .H7 I5 1962 V.2
0035	02/05/68		QP 801 .N8 M5 1963
0035	03/25/68		QP 801 .P37 H6 1963
0035	02/05/68		QP 801 .P45 A5 1964
0244	9/20/67		QP 801 .S6 D6 1965
0828	01/22/68		QP 801 .V5 S4 1967 V.6
0236	11/02/66		QP 903 .E9 1963
0007	01/30/68		QR 1 .F72 27 NOS.1-4 1966
0007	01/30/68		QR 1 .F72 27 NOS.5-12 1966
0983	1/24/66		QR 64 .5 .I5 1962
9741	05/07/68	5/22	QR 65 .C6 1964
0035	04/15/68		QR 73 .H35 1964 BIOL
2031	04/28/68	5/22	QR 73 .H35 1964 COPY 2 BIOL
3663	04/03/68	5/1	QR 73 .H35 1965
0983	9/27/66		QR 118 .A4 1962
4467	05/08/68	5/22	QR 180 .M6 V.1
4467	05/08/68	5/22	QR 181 .B6 1966
3692	05/07/68	5/22	QR 181 .C35 1965
3692	05/07/68	5/22	QR 182 .D38 1966
0891	04/23/68		QR 182 .S6 1966 Q
1020	04/18/68	5/22	QR 183 .C3 1963 BIOL
1020	04/18/68	5/22	QR 183 .K87 1965
1020	04/18/68	5/22	QR 185 .A6 C5 1967
4503	05/04/68	5/22	QR 185 .A6 S92 1965
4624	04/11/68	5/15	QR 315 .C78
0134	10/19/67		QR 360 .C8 1965
0134	10/20/67		QR 360 .S5 1965 BIOL
0134	10/19/67		QR 360 .S6 1963 BIOL
9248	05/06/68	5/22	QR 360 .W3 1961 BIOL
0986	04/17/68		R 15 .A55 B8 1963
0986	04/17/68		R 15 .A55 H3 1966
0190	05/06/68		R 15 .B93 V.29 1955
0013	02/06/68		R 117 .D8 W3 1918
0035	02/06/68		R 118 .C6 1966
0450	9/01/66		R 128 .K513 1966
0007	04/23/68		R 131 .A1 C48 2 1967
0007	04/23/68		R 131 .A1 J68 22 1967
1126	02/27/68	4/3	R 131 .A7 1949
0018	12/07/66		R 131 .G24 1929
2387	05/01/68	5/22	R 131 .S93 1931
9188	2/23/67	3/29	R 143 .C18 1926 V.1
9188	2/23/67	3/29	R 143 .C18 1926 V.2
0987	04/06/68		R 152 .T85 1966
71358	3/09/67	4/12	R 154 .B59 G2
6071	05/07/68	5/22	R 154 .B597 L85 1964 Q
8732	7/18/67	8/2	R 159 .B2 A2 1871
2387	05/01/68	5/22	R 487 .B6 1963
4501	02/02/68	3/6	R 489 .C54 A4
2387	05/01/68	5/22	R 489 .H21 J6 1964
0943	10/14/67		R 489 .H3 K4 1966
73464	6/26/67	7/19	R 489 .L6 D4 1963
0021	4/24/67		R 489 .O7 C8 1940
0016	01/29/68		R 723 .D77 1965
0190	04/23/68		R 737 .B79 1966
6856	04/29/68	5/22	R 856 .S43 1967
0007	04/10/68		R 895 .A1 A4 6 1967
6856	04/29/68	5/22	R 895 .Y3 1965
11652	04/16/68	5/15	RA 410 .A1 C6 1962
1700	05/13/68	5/22	RA 410 .M5 1960
1700	05/13/68	5/22	RA 410 .S6 1961
0035	03/05/68		RA 418 .F7 1963
0035	02/01/68		RA 790 .W5 1968
9832	04/15/68	5/15	RA 962 .F7 1963
0028	6/22/67		RA 963 .J66 1875
1651	04/28/68	5/22	RA 975 .S9 1967
0986	04/17/68		RA 981 .A2 C58 1967
0035	01/26/68		RB 113 .G8 1966 COPY 2
0035	03/07/68		RC 180.1 .D3 1963
0244	8/17/67		RC 261 .U46 1964
2041	04/30/68	5/22	RC 327 .I5 1961
0007	03/26/68		RC 367 .A35 26 1965
0007	03/26/68		RC 367 .A35 27 1966
0007	04/15/68		RC 367 .A35 28 1967
3124	04/12/68	5/15	RC 388 .C78 1965
0198	05/13/68		RC 438 .A4 1966
1729	05/03/68	5/22	RC 438 .F6 1961
0990	05/01/68		RC 439 .U4 1967

Fig. 6

Keypunching and verifying follow; the computer then compares the call numbers of returned books with those recorded earlier and all which match are cancelled to complete the cycle.

As will be shown, these procedures are as technically and operationally complex as they are conceptually simple and straightforward.

Preparation of Identification Cards

Prior to introduction of the new system the privilege of using the University's libraries had been, at least to some extent, informally controlled. Students in various categories carried identification cards but faculty and administrative and research personnel did not, and even students were rarely asked to establish their right to use the Library. Introduction of the computer system required not only complete and formal organization of the roster of those permitted to use the Library but provisions for year to year continuity in a mobile, changing population. Such tasks, as stated before, are unsuited to a doctoral candidate but perforce were preformed by him, there being no other person available.

The need for explicit determination of those to be permitted access to the Library led to a variety of internal debates and necessary managerial decisions, which the investigator could initiate and press for but not himself make. Preparation of the roster of faculty, while relatively easy, still required careful screening of the Directory, not only because of continual change but for decisions about various kinds of peripheral people: part-time faculty, Evening College appointees, research associates and assistants, post-doctoral fellows, off-campus personnel at the Applied Physics Laboratory in Howard County, faculty at the School of Advanced International Studies in Washington, and others. Analogously, management decisions were necessary for students at Goucher College, for employees

at various levels in the organization, and for those in the general community to whom guest privileges were extended. Decisions regarding ID cards for students, reasonably simple as to roster, became complicated through a desire to have each undergraduate's card bear a photograph and to have the cards laminated with clear plastic. These needs, different from all other classes and bearing no relation to needs of Library circulation control, created serious complications in preparation and the glare surface of the lamination was later found to cause difficulties in photography at time of charge-out.

In these ways an "official" roster finally was prepared and the data keypunched on cards, read on to tape, and merged by the several categories, each identifiable by appropriate brackets of assigned numbers. These data were then printed out on fan-fold for proofreading, editing, and correcting.

Concurrently with these efforts, the printed cards were designed and printed on continuous scored forms, with number sequences as part of the printing process. Differences in imprints and color -- and in the case of Evening College and Summer School students, an extra digit -- were used to differentiate the various categories of library users. Preprinting of the numbers, it may be noted, made necessary exact and continuous matching as the computer printed names on the card forms; control of this was provided by an additional computer print-out of each ID number beside the preprinted number and observation of continued matching. No problems have been encountered in this process.

The continuous form cards were then separated and distributed either by mail or during registration.

Preparation of computer programs for these procedures was complicated by several factors. No skilled programmer was available and the investigator was required to write his own, a necessity further confounded by the different formats of already programmed information. For example, punched cards for students were available but these were multi-card sets with variable field locations, not amenable to simple adaptation. In all, including carry-over tasks for the second and third years of ID card preparation, some 30 to 40 programs have been written.

Procedures for the preparation of second and third year cards have been as described above, with new and different number assignments to make old cards obsolete and unusable. However, carry-over provisions have been necessary to link those who borrow in a preceding year and do not return the borrowed items until the current year. Again, the investigator himself has been deeply involved. A resident programmer is badly needed in the Library under the direction of the Systems Analyst already employed.

Large universities no doubt have already struggled through procedures such as these but the experience here was edifying and may serve as a kind of warning to other institutions contemplating computer procedures in their libraries. We at Johns Hopkins have regarded this as a small university and it has come as something of a shock to discover that those entitled to use the Eisenhower Library number almost 20,000.

It is appropriate also to reiterate that engineering and implementation tasks like those described above are incompatible with pursuit of a Ph.D.

The Photographic Process

The camera shown in Figure 3 is a Recordak Model E Planetary Microfilm device, modified for the purpose by removing the camera from the supporting

stand. The unit comprises the film transport system, a variable focus lens, and electric relays for film advance after each exposure. The amount of film to be advanced can be selected.

Much preliminary experimentation with standard microfilm led finally to adoption of 100 foot rolls of "Plus-X" 35 mm. Eastman film. Most microfilming is concerned with sharp black and white contrast and emulsions are designed primarily for that purpose but these proved unsuitable for use here because of the variable condition of call number labels, ranging from new ones to those soiled by repeated use. The film selected therefore required sensitivity to varying tones for which the Plus-X, not a microfilm material, proved to be the best compromise.

Films designed for maximum contrast also do best when intense artificial lighting is used and this was deemed aesthetically and practically undesirable in the environment, to which much architectural attention had been given. Indeed, original plans to locate the camera in its designed overhead position were negated for this same reason: to preserve the decorative integrity of the area. The under-table mount and prism were made necessary by this decision.

Accordingly, natural lighting slightly reinforced by a single overhead spot floodlight is used. At the first location chosen for the camera some problems were encountered from changes in natural lighting. The main entrance of the Eisenhower Library faces east and the facade is largely of glass; early morning sunlight sometimes caused overexposure and it was necessary to move the camera to another position. No further difficulty has been experienced on this account.

Analogously, considerable cut and try experimentation was made with various lenses, because of the short focal distance and need for fairly

wide field. These trials led back to the regular lens as best for the purpose. The present distance from the lens to the spines or fronts of the books and ID cards to be photographed is 46 inches, the depth of the field is from 4 to 5 inches, and the maximum width of field is 18 inches. Position of objects to be photographed is assured by tolerance lines on the surface of the circulation desk and by limiting the permissible width of field to 12 inches, well within the maximum.

The supply chamber of the camera holds one 100-foot roll, portions of which may be removed for processing as they are exposed. Normally, exposed film is removed each morning and developed and fixed immediately. New rolls are supplied to the camera in response to a buzzer which sounds when the reel is within 3 feet of the end. There is, however, a footage indicator and reels are monitored and changed in the afternoon when necessary to insure that enough film will be available to carry through the night. The excess film in such cases is simply thrown away.

A simple hand technique is used for developing and fixing the exposed film. Automatic film processing was used during the trial period but was found to be less reliable, as well as more costly to install, and the hand technique remains the standard method. No photographic image has ever been lost in the development stage.

Circulation Control Operations

Operation of the system has presented a variety of problems. There is, first of all, a sequential requirement which had not been fully comprehended at the outset. Not infrequently, the same books are involved in more than one transaction on the same day. One borrower charges out a book, and within a few hours or minutes returns it; it is almost immediately

borrowed again by another patron and, surprisingly enough, this may happen yet again within the same short period. And a patron who has had a book for some time may return it in company with another person who wishes immediately to charge the item out on his own ID number.

The computer program, as noted above, records charge-outs as they occur and cancels the charge to that patron by matching the call number on discharge. It is essential, therefore, that the sequences of charge-out -- discharge - charge-out -- discharge appear in the input card deck exactly in the order in which the transactions occur. With a single camera, as in the Eisenhower Library system, this presents no problem but if two or more cameras were used changes would be necessary. It would be necessary to interconnect the cameras electrically or to adopt some other procedure to insure continuity. In any case the problem does not appear to be insurmountable.

A second camera had, in fact, been contemplated for a reason which appropriately may be explained here, since operational problems were involved.

The computer, again as previously said, cancels charge-outs by matching discharged call numbers. If each of these two transactions is properly photographed and if the data are accurately keypunched, the cancellation will be made properly. But if there is an error in <u>either</u> of the two call numbers, the cancellation will <u>not</u> be made; the item will still show on the circulation print-out and the borrower will "owe" the book to the Library until the checking procedures described have been carried out. Call numbers, as is well known, abound with redundancy of the kind that permits a human reader to identify slightly different call numbers as belonging to the same book but this does not satisfy the computer. It requires an <u>exact</u> match to cancel, thereby imposing very strict quality control requirements,

a stringency which was not fully comprehended until the system became operational.

Much more is reported below on quality control procedures and an altogether new, self-checking concept. It may be sufficient to report here that the program regularly prints-out all discharge records which do not match against previous charge-outs; these items are scanned visually and most are matched and cancelled; a few require more diligent trouble shooting by Library staff.

A returned item which escapes attention at the circulation desk and is reshelved without being photographed is a more serious matter. In such cases the book continues to appear on the circulation print-out day after day; if someone else borrows the book, the second transaction record replaces the first and all is well, but if no one borrows the item it remains on the circulation list until the shelves and list are checked prior to issuance of overdue notices.

Concern about bypassed discharges at one time led to consideration of a second camera for discharges alone, the rationale being that provision of a chute leading directly to the second camera would insure against the omission of any discharge transaction. However, procedures at the circulation desk have been "tightened up" in various ways (see below), and a second camera has not been installed, although one has been purchased as a back-up.

Much earlier in this report there was discussion of the intrinsic difference between the traditional "bibliophilic" inclinations of library staff in contrast to the new demands of an integrated system. Nowhere is this better illustrated than in the functioning of circulation staff. In

the former branch libraries the collections were very much smaller, staff performed much more autonomously, and their services, particularly to faculty, had altogether different qualities, in searching, ordering, referencing, consulting. More pertinently for this discussion, transactions did not demand any great meticulousness; an error in handwriting a call number -- there must have been a great many -- really didn't matter; it could be matched visually or for that matter by recollection; if a book was reshelved without going through discharge, that did not matter either, for there was no circulation list and few got overdue notices.

The new system -- one could say the same thing of any new system -- made it necessary to change all this and the change has not been easy. For once personalized services there must now be substituted recognition that every single transaction must conform meticulously to the requirements of the system; there must be no exceptions. Those experienced in computer systems will at once understand the meaning of this inexorable demand. It can be met by system design to circumvent human error but there still remain transitional problems with staff; they must be overcome and they are a very real part of any installation like this one at Johns Hopkins.

During the first two years of operation a variety of operational accidents and errors plagued the system. Early in 1966 a janitor, while servicing the area at night, changed the lens setting of the camera; the error was not discovered for a full day and all of the transactions for that period were lost. Since then a housing enclosing the camera has made it impervious to this kind of mishap.

Later, in the spring of 1967 during peak year-end operation, an inexperienced circulation desk assistant changed film rolls and in doing so inadvertently knocked the film-supporting platen off its bearings.

This meant that film subsequently exposed was not held flat in the focal plane; for about four days all film was overexposed and much of the information it contained was lost. Strenuous efforts to retrieve the missing information resulted in additional days of delay, while still more time was lost in keypunching obscure film images under peak load conditions. The circulation list print-out fell more than two weeks behind for a time. Two lesser incidents involving operational mishaps are documented further along in this Report (p. 48).

The seriousness of system mishaps such as these requires further explication. At this stage of the operation of this particular system there is no redundancy; the photograph of the charge-out or dischage is the only record of the event; if the photographic image is lost, so is the record of the transaction. If that lost record is for a charge-out, the library is wholly dependent upon the patron; if he returns the item, as most do, the discharge transaction will appear on a listing of non-matching discharges and all is well. But if the book is not returned, it is lost to the library.

The other case, of a lost discharge record, is less serious. In these cases the circulation list will continue to show the item as borrowed but this will be detected by procedures preceding the sending of overdue notices.

The effect of this mishap upon Library staff was traumatic -- and their trauma was accompanied by heartfelt and understandable denunciation of the system. Since this egregious error all circulation desk personnel have been carefully trained in operation of the camera, including the changing of film, and printed instructions are used to reinforce that training. But at the time of stress these corrective measures could not

escape stigma: the stable door was being locked after the horse had been stolen.

Other sources of error should also be recounted. Recognition had been given at the design stage to the need for good pictures, a need as much dependent upon the objects to be photographed as upon camera and film. Not a few call number labels are illegibly written or typed, or have become soiled, blackened, or mutilated through use and all circulation desk attendants therefore had been instructed to prepare new labels in all such cases before pushing the camera switch. To do this, however, may require a patron to wait and, especially if there are others waiting and the patron has a number of books to process, the tendency to photograph "as is" is overriding. Thus, photographic imperfections of various kinds (Figures 7, 8, 9) have caused recurring difficulties in keypunching and verifying. And the fact that circulation desk personnel turn over at a high rate, often work part-time, and are short-term rather than career employees, further creates propensities for error. To repeat: computer systems emphasize the need for meticulousness and other librarians contemplating such systems should bear this in mind.

To prevent errors of the kind just described, corrective measures were introduced during the summer of 1967. These seem to have worked reasonably well, although other steps to improve microfilm projection and keypunching may have played a larger role in improving operational quality. These are described below. Dr. Donald E. Kerr, Professor of Physics, served as photographic consultant to the project during this period and gave valued and much appreciated advice.

Before turning to the subjects of keypunching and proofreading, additional discussion of the need for system redundancy is in order.

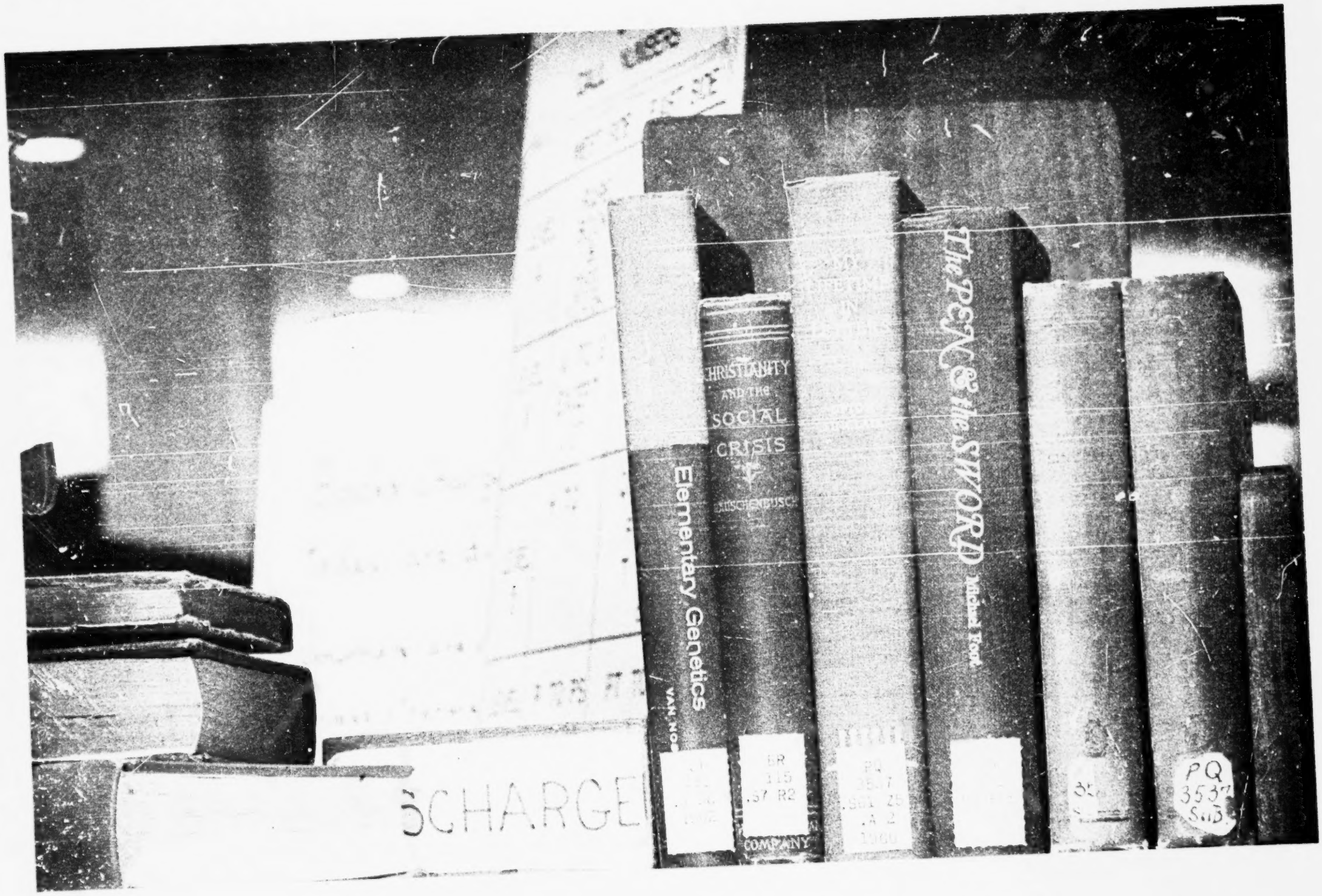

Fig. 7 Call number labels partly torn off (two books on right)

(Note: In this figure and the two which follow, the intent is simply to illustrate operational problems. The reproductions on these pages are made from half-tone plates, which have been made in turn from large blow-ups, made on positive copy equipment; they do not, therefore, adequately represent the contrast or definition of the original photographic image, as it may be seen on a good microfilm reader.)

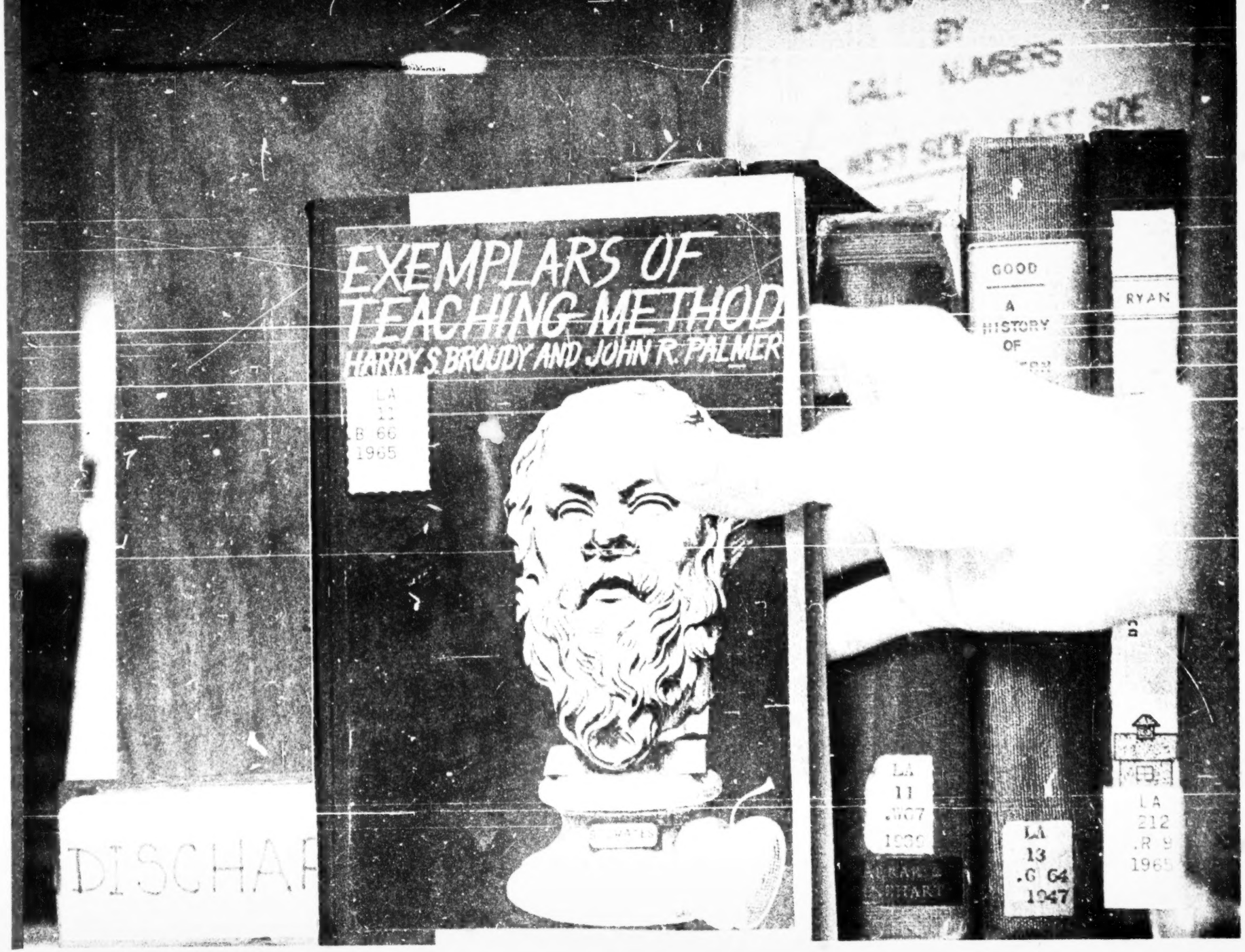

Fig. 8 Book held by hand, partially obscuring others behind

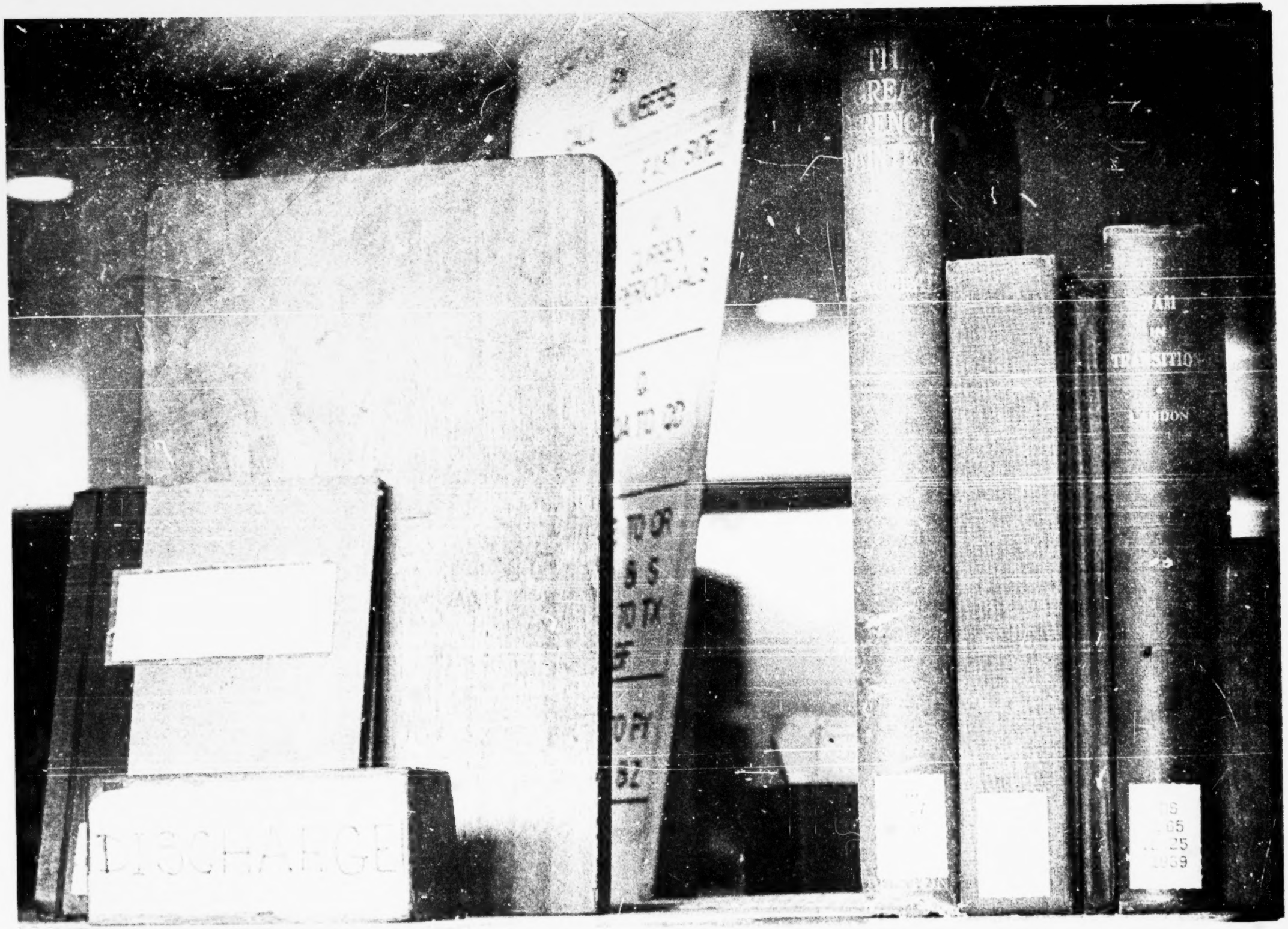

Fig. 9 Books improperly displayed, call number labels hidden

As reported above, there is no redundancy in the camera system presently used in the Eisenhower Library; there is one photograph, one developed film image, and one punch card record of each transaction. Back-up duplication could be provided by utilization of a camera capable of exposing two rolls of 16 mm. film simultaneously but this additional safeguard has not been implemented here. Parallel handwritten records, to be used only when needed, are not regarded as operationally feasible. Strictures such as these, it may be noted, are applicable to other systems as well, the IBM 1030, for example.

We can, however, conceive of a resolution to this problem through adoption of a seven-digit, self-checking redundant code number, to be used in company with optical scanning. Proposals for these innovations are presented at the end of this report. In the meantime, we have sought vigorously to achieve meticulous staff performance as the necessary ingredient of successful present system operation.

Date Due Stickers

An important part of circulation desk procedure is the identification of items properly charged out in order that they may be cleared by the guard stationed at the exit turnstile. This is accomplished in the present system by means of a specially designed pressure-sensitive adhesive label, imprinted with the proper due-date for the item being charged out. One of these is affixed to the back of each book by the circulation desk assistant (Figure 4).

While the conception and appearance of these stickers seem deceptively simple, much engineering has been required to bring this part of the system to its present state. Procurement of the stickers in the form of die-cut rolls with background preprinted in a pastel shade required considerable

investigation; so also did the means of imprinting due dates, and this part of the matter first required a decision by Library staff to adopt uniform due-date policies. Also required was a device which feeds the stickers to the attendant so that they can be taken off and pressed upon each book with minimum difficulty (Figure 10). All of these developments have been carried out successfully.

Most troublesome have been decisions about the adhesive backing of each label. The original plan, used for more than a year, utilized a pressure sensitive adhesive which would permit removal of each such label at the time of discharge. However, it was realized from the start that such an adhesive would permit borrowers as well as circulation desk personnel to remove the labels; if removed intact by a would-be thief, he could re-enter the Library and take a book out through the turnstile, using the now illegal label for his nefarious purpose.

Two steps in design were taken as preventive measures: (1) the paper stock selected was light and flimsy and (2) the labels were slit in the die-cutter; both of these steps were intended to make it difficult to remove date due labels intact. Consideration also was given to the possible use of adhesive and/or inks which would chemically change color on removal but want of time prevented carrying this idea to a successful conclusion, although it remains an attractive possibility.

Unfortunately, these measures have not worked, at least not sufficiently well to provide the security deemed necessary. Erstwhile book thieves apparently were sufficiently painstaking and patient to remove labels with a razor blade or knife and use them to steal books in the manner described.

When this became known it was decided to change the system by substituting a permanent adhesive and indicating a discharged item by use of a

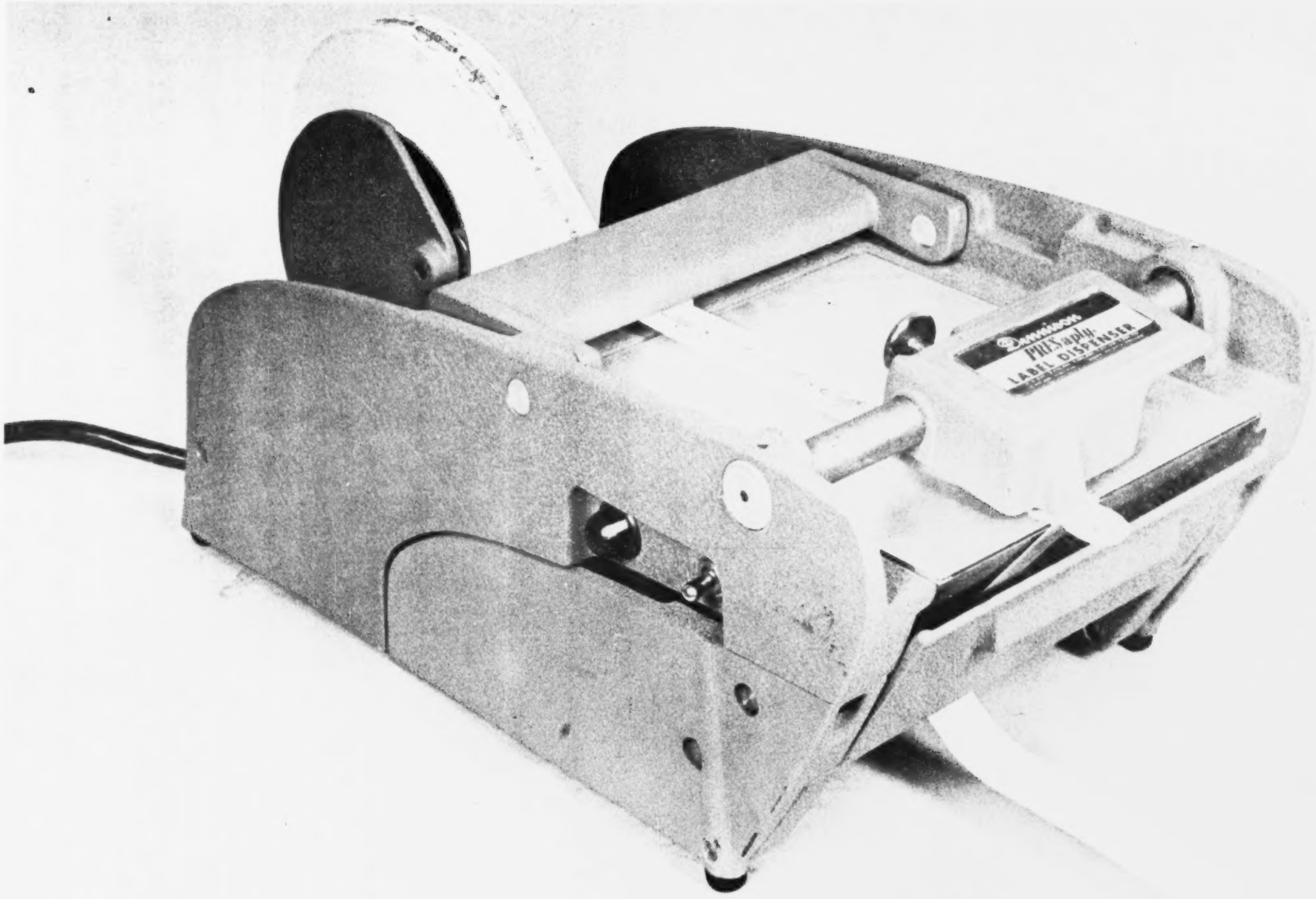

Fig. 10 Automatic dispenser for pressure-sensitive date due labels

bold "X" rubber stamped on the face of each label on a discharged book. For additional charge-outs new labels are simply placed on top of those for earlier transactions. This part of the system seems to work well.

In connection with this part of the narrative of problems of implementation an opinion may be permitted: Prior to centralization in the Eisenhower Library the Faculty Library Committee seemed to place relatively little value upon security of the collection. Indeed, with branch Libraries and multiple exits and entries, there was a custom of free access, verging upon a "help yourself" presumption, and some members of the faculty were known to keep many Library books in their own offices for years on end, there being no time limits on faculty borrowing nor adequate recall procedures.

Centralization, reinforced perhaps by a very large growth in graduate enrollment and greatly increased use of the Library, has brought with it very much greater concern for security on the part of the Faculty Library Committee. Installation of the turnstiles and much greater emphasis upon careful scrutiny by the guard has been at the behest of this Committee.

Keypunching and Verifying

The operations previously described, that is, those carried on at the circulation desk, are concerned of course with the volume of transactions, from hour to hour, day to day, and month to month. These work loads are quite variable, characterized, for example, by small between-class peaks, very heavy demands at the start and finish of the school year, and a summer slump. But the speed with which transactions are carried out by the camera has not posed a production problem at the circulation desk, where one might say there is a plethora of capacity.

The subsequent operations of keypunching and verifying (or, more accurately, proofreading), however, present a different problem, for each

book borrowed or returned must be processed and this processing must be done each day, if the print-out of books in circulation is to be kept reasonably current.

It is therefore pertinent here, before discussing operational details, to introduce two other topics: (1) the extraordinary increase in Library utilization, which had been foreseen by no one, and (2) the significance of the time lag between a charge-out and the appearance of the transaction record on the print-out.

Library Utilization

The following data on utilization of the Library during the transitional period fell short of desirable accuracy but are sufficiently good to indicate the remarkable increase to which several references already have been made.

Prior to centralization of the collection in the Eisenhower Library data on the number of items reshelved were kept for six weeks. How "typical" this period was is not known but the figures show a total of 16170 items for the period, an average of 2695 books reshelved per week.

Data since occupancy of the Eisenhower Library are much better and show the following yearly reshelving figures:

March 1, 1965 - February 28, 1966	238,107
March 1, 1966 - February 28, 1967	282,049
March 1, 1967 - February 29, 1968	371,759

Based upon weekly averages, for comparability with earlier data, the figures reduce to

2695 items reshelved per week prior to centralization

4579 items reshelved per week - first year after centralization

5424 items reshelved per week - second year after centralization

7149 items reshelved per week - third year after centralization

Thus the level of circulation activity in the new Eisenhower Library rose almost immediately by a factor of 1.7, in the second year it doubled, and since then has increased still further, multiplying the pre-centralization average by a factor of 2.65.

The peaks and valleys of these date are, in another way, just as important as averages, because of the present requirement that each day's transactions be keypunched and verified during the next day, lest the circulation print-out lose currency. Table 1, not surprisingly, shows the summer months to be slack periods, while those months near the ends of semesters are much busier, with volume roughly doubling slack period transactions.

Mundane as this information at first appears to be, there is still a point to be made: keypunching is not an easily acquired skill, nor are such operators easy to find and employ; the Library therefore cannot meet the demands of peaks and valleys by hiring students or part-time people but must staff this part of the system redundantly, with enough people to meet maximum demand. The inevitable concomitant of doing so, of course, is surplus during slack seasons. While the point is obvious, it is still relevant, given the fact that libraries are habituated to the use of students and other part-time people to meet special needs.

Work in Process Delay

The circulation control system used in the Eisenhower Library at Johns Hopkins may properly be described as a batch process: photographs are taken as transactions are made, these are accumulated for each day, that day's film record is then keypunched and verified to comprise input to the computer; the program is then run, and the new, up-to-date circulation list is printed out and copies are appropriately placed in the Library. The

number of transactions in process, that is, photographed but not yet computed, will be a function of patron demand and of the time interval between the click of the camera shutter and the appearance (or disappearance in the case of discharges) of the item on the print-out.

TABLE I

Month	Number of Books Filed 65-66	Number of Books Filed 66-67	Number of Books Filed 67-68
January	23560	29980	39534
February	24154	25581	37919
March	18086	24965	26395
April	24449	21564	28075
May	30161	30802	37453
June	25760	29449	34740
July	15699	16109	28440
August	11354	16908	30863
September	8299	15450	18020
October	14349	21806	27122
November	23298	24442	32029
December	18938	24993	31169
TOTALS	238107	282049	371759

At the time of installation of the new circulation control system it was believed that twice weekly would suffice for the circulation list print-out,

and it was felt that one copy at the circulation desk would be enough. However, experience has taught that these decisions were mistaken; now the circulation list is printed daily and in multiple copies, with carbon copies separated and placed at each floor level for easier reference by patrons.

Despite these improvements the 24-hour-plus work in process lag still represents a serious deficiency in the circulation control system, especially during peak loads. Items photographed but not yet processed are, in effect, in limbo; the data are "lost" in the system until the computer has digested and printed out a new list.* Thus, an element of uncertainty exists within the present system: a patron who cannot find the book he wants either on the shelf or on the circulation list does not know where it is; he may patiently wait until the next day or two and look again but he is just as likely to seek staff help. The burdens upon staff occuring from this source have been considerable, less with daily print-outs, of course, and also as patrons have come to understand the system better.

However, despite these improvements, the desire for on-line capability is keenly felt and the 7-digit code technique described below is intended, among other advantages, to provide this, to give the circulation desk the means of quickly retrieving information about all currently in-process transactions.

Quality Control

Earlier reference (p. 24) has been made to the requirement for exact matches between the call numbers keypunched at charge-out and discharge. While this always has been understood, the possibilities for error were for

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*Other possibilities for loss have been remarked elsewhere (p. 25).

a time underestimated and mistakes ran as high as 10 per cent of the number of transactions, again to the detriment of staff time and patience.

A number of steps have been taken to diminish the error rate:

1. The microfilm readers, because of their size, originally were located to the right of each keyboard. This required the keypunch operator to turn her head back and forth in an awkward manner conducive to error. At the suggestion of Dr. Alphonse Chapanis, Professor of Psychology, who served briefly as consultant, the microfilm readers have now been placed slantwise just above each keyboard (Figure 5), a position requiring much less shifting of the operator's eyes.

2. At the suggestion of Dr. Donald Kerr, Professor of Physics, who also served as consultant, one microfilm reader has been provided with a magnifying lens which substantially increases both the size and legibility of the projected image. Attempts have been made to secure another lens for the second reader but this is a discontinued item and the procurement effort has so far been unsuccessful.

3. Thin books bearing call number labels at front-upper-left are now photographed separately from thicker books with labels at lower-spine, the prevailing position. This rule was devised because these differences in position, when magnified and projected on the keypunch screen, had very different base lines, those at front upper-left projecting far above those at lower-spine, in a manner conducive to omission of the thin items. Separate images for these make skipping much less likely.

4. Instructions were drafted to emphasize the need for constant vigilance to protect against illegible call number labels but there is some evidence that this effort has not been altogether successful.

Computer Operations

From the beginning, the IBM 1401 magnetic tape system with 8K storage has been used for circulation control. From the standpoint of cost, this is a satisfactory machine but it does embody some limitations:

1. The requirement imposed for extensive effort in a low-level programming language (Autocoder) has caused both programming delays and disproportionately high software costs.

2. The 1401 magnetic tape system does not have random access storage capability; this is a relatively minor limitation which will become more restrictive as new systems are implemented.

3. Operation of the 1401 requires standard operating procedures which must be meticulously observed, a limitation which this machine shares with others of its generation. This limitation has been compounded by frequent personnel changes in the Computer Center, where new employees often fail to practice necessary care.

In preceding pages mention often has been made of necessary sacrifices in behalf of implementation. Such sacrifices were made in this part of the system as well, as a subtle consequence of the computer cost system which has been applied during the period. As an instance, although the rate for the 1401 has been uniformly $35 per hour, day and night charges for operation have been effectively different, because of differences in ways of accounting for computer time. During the day <u>total</u> time from job-on to job-off is charged for but at night the only time charged is that recorded by the central processing unit clock of the computer, a shorter chargeable interval. Feeling the pressures of a limited budget, all computer runs were made late at night, with attendant hardships. Charges for developmental runs also were made and these too imposed restraints for

necessary economy.

During the initial period, print-outs were processed twice weekly, as reported elsewhere. When daily runs were begun, a concurrent effort was made to turn the operational routine over to Computer Center personnel. This was followed by several postponements in providing service to the Library in favor of research runs, a shifting of priorities which led to some awkwardness. Happily, the administration intervened to achieve the understanding that Library needs must be scheduled at an appointed time each day, regardless of other demands. Once this understanding was reached, service by the Computer Center attained a satisfactory level marred only by personnel changes to which reference already has been made.

Like computer centers in other universities, the Center at Johns Hopkins is actively planning for the next generation of machines. The increased potential of the machines being considered will give new capabilities to the Eisenhower Library. These possibilities are discussed in Section III.

Simulated Borrowing Study

The efficacy with which a circulation control system performs its functions can be sensed in a number of ways in the day-to-day operations of a library. Its operating characteristics may be sensed directly in some areas, and indirectly in others. The staff at the circulation desk are directly and acutely aware of the manner in which the system adapts to and accommodates peak-load conditions, for example, or of the adequacy and ease with whcih it provides circulation information. In other cases, the effects are perceived indirectly: discrepancies or mistakes which occur in the handling of transactions, for instance, may be discerned only when special ancillary listings from the daily computer run are routinely pro-

cessed, or when library shelves are checked prior to the dispatch of overdue notices. The feedback from all such operational sources is continuous and significant. In the implementation of the present system, this kind of information has been the prime input for adjustments of the operating parameters of the system, and for procedural modifications.

Despite the variety and ubiquity of such natural feedback, however, there is a place, and a need, for careful investigative procedures to provide management control information on system performance. There are obvious reasons for this. The feedback from operating functions is very often non-quantifiable; or if it is quantifiable, it may be far from clear what the proper data base is, what the relevant denominator should be for a meaningful operating index. Data originating at different points may be partial and apparently contradictory, leading to different interpretations and making the effective determination of causes difficult or impossible. Above all, such inputs are liable to subjective coloration by the persons involved, leaving any precise conclusions in limbo. For such reasons, a completely objective, carefully controlled investigation, where it can be managed, is a very desirable adjunct.

The limitation on such procedures is, of course, one of cost. The investigation must be carefully designed and planned, and to do this adequately is a time-consuming process; in addition, the supervising and staffing costs for the operation are generally not negligible. Good information is seldom cheap.

These few remarks summarize, then, both the reason for the investigation which has been carried out, and the reason for concentrating it on a single locus. The aim of the investigation was taken to be that of elucidating the most critical aspects of operation of the system. In

selecting the area of concentration, therefore, those aspects of the system which seem to be unproblematical or to have definite plus values were passed over in favor of the aspects which appeared least known or most problematical. Such matters as measuring the throughput rate for patrons at the front desk, or the utility of the information provided per dollar of operating costs, have been left for possible future consideration, and the investigation has concentrated solely on the matter of the reliability of the recording and transcribing processes used in the system.

In approaching this objective, the viewpoint taken has been a practical engineering one. It has been the aim to test the system on a "macro" basis, rather than a "micro" one; that is, the aim has been to test overall performance, rather than to examine the efficiency of component operations. For this reason, and in order to attain complete objectivity, the plan adopted has been to employ individuals having no connection with the Library to conduct a series of actual borrowings and returns of designated items, thus simulating the activity of the users of the Library. The test borrowings differed from actual usage only in that complete information was recorded on all aspects of the transactions by the persons conducting the test, for later comparison with the formal output listings of the system itself.

Details of the procedure were worked out, and undergraduate students were hired to conduct the test transactions during the period from December, 1967 to May, 1968. It may be noted in passing that this was not an ideal time for the testing; the man in direct charge of the circulation control operation left the employ of the University during this period and was replaced by a successor who had only a week's overlap in time with the man departing; other changes in personnel took place during the period, and,

in addition, all of the personnel and equipment associated with the operation were removed during this time to a different location in the Library building. Despite these disruptions it was felt that it was imperative, at this time, to obtain some data of the sort described, and the test operations were continued throughout this period.

To assure the validity of the results, all test transactions were conducted without the knowledge of the personnel at the circulation desk or in the circulation control operating section. The instructions for the students were meticulous on this point. To quote from the written directive prepared for them:

> "In all dealings with the charge-out desk, and for that matter, with any other operational branch of the Library, conduct yourself exactly as you do in your everyday capacity as an individual student. If this survey is to be meaningful, it is not only desirable but imperative that the transactions represented in it be handled in the normal manner. To this end, it is obviously essential that you refrain from calling the attention of Library attendants to this activity as such; and, in the same sense, that you refrain from carrying data sheets around the Library in a conspicuous manner, from obviously making notes on observations at the circulation counter, etc."

The test operations proceeded in the following manner: A separate $8\frac{1}{2}$" X 11" data sheet was prepared for each book to be handled, spaces being provided to record pertinent bibliographic information concerning the item, all information relevant to the borrowing and return transactions for it, and the data subsequently abstracted from the system output listings for the same item. It is a matter of common knowledge that in the Eisenhower Library a large percentage of the holdings virtually never circulate; since it was our objective to test performance with respect to transactions as they actually occur, and therefore with respect to the subset of the collection which does actually circulate, the sample

was chosen, using a table of random numbers, from the set of items which had previously been observed to circulate at least once, rather than from the entire holdings. The items so selected were entered by call number, one to a data sheet; the students took the sheets to the stacks, searched for each book, and, when they located it, proceeded to carry out the transactions and record the data as indicated above.

After completion of the data collection phase, the results were analyzed and tabulated; examinations of the pertinent microfilm records of circulation were made at this point where this was necessary to categorize a datum correctly. The results are shown in Figure 11.

Of the 553 complete transactions tabulated, a total of 532, or 96.2%, are shown in category (1) as being handled correctly in every respect. Of the remaining 21 for which anomalies were observed, 8 cases, or another 1.5%, were observed to have minor discrepancies in the recording of the call number for the charge records, but the items were nevertheless discharged when the books were returned. Items in the remaining three categories would, in general, require some tracing to be correctly disposed; this tracing would be accomplished as a part of routine procedures in some cases, and would not in others. It will be noted that difficulties in the legibility of the call numbers on poor labels is a significantly higher factor in these latter categories. This persistent problem has been reduced by corrective measures which have been instituted but, as can be seen, cases of it still occur.

It should be emphasized that the tallies shown in Figure 11 represent completed borrow-and-return transactions; that is, each unit in the count represents a complete borrowing cycle for one book. The record is counted as a discrepancy or an error if an anomaly occurs at <u>either</u> the charge or the discharge transaction.

Figure 11

Data from completed borrow-and-return transactions, in test of circulation control system

	Legibility of call number label			Total Trans-actions	Percent of total transactions
	OK	Not readily legible	Illegible		
(1) Correctly charged and discharged	510	22	0	532	96.2%
(2) Discrepancy in charge record, but item discharged correctly	7	1	0	8	1.5
(3) Correct charge record, but item not discharged when returned	2	1	0	3	0.5
(4) Discrepancy in charge record; and item not discharged when returned	2	1	0	3	0.5
(5) No charge record located	5	0	2	7	1.3
	526	25	2	553	100

Two mishaps which occurred during the period of time that the study was in progress affected transactions under the test program. On April 1, an employee climbed up on the circulation counter by first stepping on the shelf supporting the circulation camera. His weight was sufficient to alter the image alignment of the camera and cause some film records to be partially obscured. Of a total of 29 transactions under the test program which happened to be conducted during the period before this was corrected, 17 were recorded correctly and 12 were not recorded or contained errors. Since this condition was correctible and seemed obviously to come under the head of "debugging", all 29 transactions were excluded from the final compilation. On the other occasion, which occurred during the racial riots in Baltimore, on April 6-10, a substitute at the circulation desk with no prior experience with the equipment attempted to change the film, in the absence of all regular employees due to regulations stemming from the emergency. A total of 13 test transaction records were all lost due to this circumstance; these have similarly been excluded from the compilation.

SHELF LIST ON TAPE

Processing of the Main File

The project for converting the shelf list of the Library to magnetic tape has already been mentioned and summarized in Section I of this report. Details of the procedures designed for accomplishing this task, as well as the specific objectives which led to the planning for it, have been described in earlier Progress Reports. To recapitulate briefly, these procedures comprised:

1. Producing a microfilm copy of all cards in the shelf list catalog.

2. Typing, in a machine-readable font, the essential items of information abstracted from each record. The abstracting and recording process was performed directly from the microfilm record, viewed on a suitable microfilm reader situated alongside a typewriter equipped with the necessary special font. The essential elements of information recorded for each record were:

   a. The call number. (The call numbers used in the Eisenhower Library are basically Library of Congress type designations, modified in some cases to suit local requirements.)

   b. Main entry

   c. Title -- somewhat shortened in the case of quite lenghty titles.

   d. Collation -- the primary physical characteristics of each item. This field of information includes three sub-fields:

      (1) Number of pages (or the number of volumes, in the case of a multi-volume set)

      (2) Height in centimeters (or height and width, if an odd-shaped book)

(3) Number of copies in the Eisenhower Library.

3. Scanning of the typed copy on an optical character recognition device. The output of the scanning process went directly onto magnetic tape, by means of a tape unit on-line with the scanner. The optical scanning was performed at the facilities of the Rabinow Engineering Corporation, now a subsidiary of Control Data Corporation.

The final product of this processing is known locally as SLOT, an acronym standing for "shelf list on tape".

As received from the scanner, the output on magnetic tape was in fixed-length records, in "unblocked" tape format -- that is, one line of output to each physical tape record. In this form, the total file was contained on twelve 2400-ft. reels of magnetic tape. In order to facilitate tape-to-tape processing and output utilization, it was highly desirable to condense the file onto fewer tape reels, if possible; and in addition it was clearly necessary to submit the file to very careful checks and reviewing procedures. Because of the very large size of the file, this reviewing task could only be done efficiently by computer processing. Accordingly an extensive computer program was designed for reformatting and checking and revising every element of every record in the file. The reformatting was to a highly blocked variable-record-length, variable-field length format, with a table generated at the beginning of each record giving the relative address of each field. The complete file, following this reformatting, now occupies just slightly more than two reels of tape. The checking and revising procedures included such matters as verifying field count, examining for inadmissible characters, checking for sequencing by call numbers, searching for special symbols, and so on. In every case,

the program, after diagnosing an anomaly, either took appropriate corrective action on the record, where it was feasible to write such action into the programming, or else sorted the record in question into one of several output files, for subsequent individual review and processing. An example of such an output file is provided by the case in which a typist, transcribing the records from microfilm, encountered a record which the abstracting and transcribing rules did not seem to cover, or which she was unable to handle adequately for any other reason. (The most frequent case in this category is that in which the original shelf list card was printed in Cyrillic characters, or any other non-Roman alphabet.) In all such cases, the typist, following directions, entered a special symbol in the record; and, according to plan, the general processing program was written to cause all records containing this symbol to be written on the appropriate one of the several separate output tapes, for subsequent revision. The number of records of this type encountered comprise 2.1% of the total, very close to the original estimate for this category. The records on all other special output files, including such things as incorrect field counts, call numbers which do not conform to the "grammar" specified, special out-of-sequence conditions, etc., amount to about 1% of the total.

The program to accomplish this processing was written in a language called "BEEF", developed by Westinghouse Electric Corporation and modified and adapted by us, for the above purposes. The compiler for this language, suitably adapted, is now resident on the University Computing Center system tapes for the IBM 7094. The complete program described above was run on the 7094, taking a total of $6\frac{1}{2}$ hours of execution time. A sort of the file on the main entry field has also been executed, and it was gratifying to find that this could be accomplished, for the entire file, using the special

variable format developed, in just $1\frac{1}{4}$ hours of machine time. Listings of the complete file, both in order by call number and in order by main entry, have been produced and are available for reference in the Library. Samples of each listing are shown in Figures 12 and 13.

Updating

The conversion process for producing machine-readable records to update SLOT is basically the same process designed for the original conversion of the main file, except that the transcribing is done directly from hard copy, rather than from microfilm. A suitable electric typewriter, equipped with the appropriate OCR font, was secured for the purpose and situated in a convenient location in the Technical Service area of the Library. (A second such typewriter has recently been purchased, to provide back-up and increased capacity.) For each newly cataloged item, a catalog card is routed to this processing station, where the information for the updating record is abstracted and typed on continuous-form, pin-feed paper, of suitable quality for optical scanning. The abstracting and typing of the necessary elements of information are done by a person with library training. The completed typed copy is forwarded for direct conversion to magnetic tape on the optical scanner.

Mention was made in the first Section of this Report of the difficulties inherent in forming the interface between traditional library practice and data processing technology. Nowhere is this more true than in the design of these records for new inputs to the computer file. A particular reason for this is the increased latitude and flexibility available in the planning of these records. In planning the conversion of the main file, the constraints imposed on the individual record form were quite stringent,

JOHNS HOPKINS LIBRARY SHELF LIST MARCH 1968

B	67.M33 1960	MADDEN,EH ** THE STRUCTURE OF SCIENTIFIC THOUGHT ** 381P 25 ZZ
B	67.M4 1961	MARGENAU,H ** OPEN VISTAS ** 256P 22 ZZ
B	67.M48 1958	MEHLBERG,H ** THE REACH OF SCIENCE ** 356P 24 ZZ
B	67.M5 1944	MERCIER,C ** LA VIE DE L UNIVERS ** 281P 19 ZZ
B	67.M57 1950	MICHEL,PH ** DE PYTHAGORE A EUCLIDE ** 699P 26 ZZ
B	67.M62 1906	MILHAUD,GS ** ETUDES SUR LA PENSEE SCIENTIFIQUE CHEZ LES GRECS ET CHEZ LES MODERNES ** 273P 16 ZZ
B	67.M63	MILHAUD,G ** NOUVELLES ETUDES SUR L HISTOIRE DE LA PENSEE SCIENTIFIQUE ** ZZ ZZ ZZ
B	67.N14	NAGEL,E ** ON THE LOGIC OF MEASUREMENT ** 91P 23 ZZ
B	67.N16 1954	NAGEL,E ** SOVEREIGN REASON ** 315P 22 ZZ
B	67.N18 1961	NAGEL,E ** THE STRUCTURE OF SCIENCE ** 618P 23 ZZ
B	67.N48 1951	NEUGEBAUER,O ** THE EXACT SCIENCES IN ANTIQUITY ** 191P 24 ZZ
B	67.N48 1957	NEUGEBAUER,O ** THE EXACT SCIENCES IN ANTIQUITY ** 240P 24 ZZ
B	67.N49	NEURATH,O ** LE DEVELOPPEMENT DU CERCLE DE VIENNE, ET L AVENIR DE L EMPIRISME LOGIQUE ** 57P 25 ZZ
B	67.N65 1950	NICOD,J ** FOUNDATIONS OF GEOMETRY AND INDUCTION ** 286P 22 ZZ
B	67.N67	NICOLLE,C ** LA NATURE ** 134P 19 ZZ
B	67.N87	NORTHROP,FS ** SCIENCE AND FIRST PRINCIPLES ** 299P 22 2
B	67.P21 1961	PALTER,RM ** TOWARD MODERN SCIENCE ** 2V 21 ZZ
B	67.P22 1946	PAP,A ** THE A PRIORI IN PHYSICAL THEORY ** 102P 23 ZZ
B	67.P24 1962	PAP,A ** AN INTRODUCTION TO THE PHILOSOPHY OF SCIENCE ** 444P 24 ZZ
B	67.P47 1957	PETER,R ** REKURSIVE FUNKTIONEN ** 278P 24 ZZ
B	67.P58	PICARD,J ** ESSAI SUR LES CONDITIONS POSITIVES DE L INVENTION DANS LES SCIENCES ** ZZ ZZ ZZ
B	67.P71	PLANCK,MK ** THE UNIVERSE IN THE LIGHT OF MODERN PHYSICS ** ZZ ZZ ZZ
B	67.P72	PLANCK,MK ** WHERE IS SCIENCE GOING ** 221P 21 2
B	67.P73V6 1961	VOGEL,P ** ZUM PHILOSOPHISCHEN WIRKEN MAX PLANCKS ** 255P 25 ZZ
B	67.P75	POINCARE,H ** DERNIERES PENSEES ** 258P 18 ZZ
B	67.P8	POINCARE,H ** THE FOUNDATIONS OF SCIENCE ** 553P 24 ZZ
B	67.P82 1958	POLANYI,M ** PERSONAL KNOWLEDGE ** 428P 25 ZZ
B	67.P821 1959	POLANYI,M ** THE STUDY OF MAN ** 102P 19 ZZ
B	67.P87 1959	POPPER,KR ** THE LOGIC OF SCIENTIFIC DISCOVERY ** 479P 23 ZZ
B	67.P91 1961	PRICE,DJ ** SCIENCE SINCE BABYLON ** 149P 22 ZZ
B	67.R18	RAMSEY,FP ** THE FOUNDATIONS OF MATHEMATICS AND OTHER LOGICAL ESSAYS ** 292P 22 ZZ
B	67.R22	RAMSPERGER,AG ** PHILOSOPHIES OF SCIENCE ** 304P 21 ZZ
B	67.R32 1961	READ,J ** THROUGH ALCHEMY TO CHEMISTRY ** 206P 19 ZZ
B	67.R35	REICHENBACH,H ** FROM COPERNICUS TO EINSTEIN ** 123P 24 ZZ
B	67.R352 1959	REICHENBACH,H ** MODERN PHILOSOPHY OF SCIENCE ** 214P 22 ZZ
B	67.R355 1948	REICHENBACH,H ** PHILOSOPHY AND PHYSICS ** 13P 24 ZZ
B	67.R36 1949	REICHENBACH,H ** THE THEORY OF PROBABILITY ** 492 25 ZZ
B	67.R39 1950	RENOIRTE,F ** COSMOLOGY ** 256P 21 ZZ
B	67.R45	REYMOND,A ** HISTORY OF THE SCIENCES IN GRECO-ROMAN ANTIQUITY ** 245P 19 2
B	67.R5 1961	RHYS,HH ** SEVENTEENTH CENTURY SCIENCE AND ARTS ** 137P 23 ZZ
B	67.R53 1962	RICKERT,H ** SCIENCE AND HISTORY ** 161P 24 ZZ
B	67.R55	RILEY,IW ** FROM MYTH TO REASON ** 327P 21 2
B	67.R57 1958	RITCHIE,AD ** STUDIES IN THE HISTORY AND METHODS OF THE SCIENCES ** 229P 23 ZZ
B	67.R59	RITCHIE,AD ** SCIENTIFIC METHOD ** ZZ ZZ ZZ
B	67.R7	RUEFF,J ** DES SCIENCES PHYSIQUES AUX SCIENCES MORALES ** ZZ ZZ ZZ
B	67.R96 1946	RUSSELL,BR ** PHYSICS AND EXPERIENCE ** 25P 18 ZZ
B	67.S2 1962	SAMBURSKY,S ** THE PHYSICAL WORLD OF LATE ANTIQUITY ** 189P 23 ZZ
B	67.S24 1948	SARTON,G ** THE LIFE OF SCIENCE ** 197P 22 ZZ
B	67.S25 1949	SAUER,W ** GRUNDLAGEN DER WISSENSCHAFT UND DER WISSENSCHAFTEN ** 437P 25 ZZ
B	67.S3 1963	SCHEFFLER,I ** THE ANATOMY OF INQUIRY ** 332V 22 ZZ
B	67.S33 1963	SCHLESINGER,G ** METHOD IN THE PHYSICAL SCIENCES ** 140P 23 ZZ
B	67.S34 1949	SCHLICK,M ** PHILOSOPHY OF NATURE ** 136P 23 ZZ
B	67.S36 1952	SCHRODINGER,E ** SCIENCE AND HUMANISM ** 68P 19 ZZ
B	67.S5 1957	SHAH,I ** ORIENTAL MAGIC ** 206P 24 ZZ
B	67.S55	SHORR,P ** SCIENCE AND SUPERSTITION IN THE EIGHTEENTH CENTURY ** 82P 23 ZZ
B	67.S57 1959	SINGER,EA ** EXPERIENCE AND REFLECTION ** 413P 22 ZZ

Fig. 12

JOHNS HOPKINS LIBRARY SHELF LIST IN ORDER BY AUTHOR

Z 697.M4A1	ABENDROTH,R ** DAS BIBLIOGRAPHISCHE SYSTEM DER NATURGESCHICHTE UND DER MEDIZIN ** 2V 24 ZZ
HQ1612.A2	ABENSOUR,L ** LA FEMME ET LE FEMINISME AVANT LA REVOLUTION ** ZZ ZZ ZZ
PH2145.B.W7A14	ABENSOUR,L ** LE FEMINISME SOUS LE REGNE DE LOUIS-PHILIPPE ET EN 1848 ** 337P 18 ZZ
PB1404.A21	ABERCIUS, ** S. ABERCII VITA ** 154P 17 ZZ
PB1404.A22	ABERCIUS, ** S. ABERCII VITA ** 50P 17 ZZ
Z 53.P72A1	ABERCROMBIE,D ** ISAAC PITMAN ** 23P 24 ZZ
BJ1025.A3	ABERCROMBIE,J ** THE PHILOSOPHY OF THE MORAL FEELINGS ** ZZ ZZ ZZ
P 4042.A3 1932	ABERCROMBIE,L ** POETRY ** 64P 19 ZZ
PC4754.A31	ABERCROMBIE,L ** THOMAS HARDY ** ZZ ZZ ZZ
PC6001.A14 1930	ABERCROMBIE,L ** THE POEMS OF LASCELLES ABERCOMBIE ** 550P 20 2
PC6001.A14D2 1913	ABERCROMBIE,L ** DEBORAH ** 60P 20 ZZ
PC6001.A14E5 1912	ABERCROMBIE,L ** EMBLEMS OF LOVE ** 213P 19 ZZ
PC6001.A14E7 1926	ABERCROMBIE,L ** AN ESSAY TOWARDS A THEORY OF ART ** 114P 19 ZZ
PC6001.A14I1 1926	ABERCROMBIE,L ** THE IDEA OF GREAT POETRY ** ZZ ZZ ZZ
PC6001.A14P9 1923	ABERCROMBIE,L ** PRINCIPLES OF ENGLISH PROSODY ** ZZ 19 ZZ
PC6001.A14P9 1929	ABERCROMBIE,L ** PROGRESS IN LITERATURE ** 52P 19 ZZ
PC6001.A14P9 1932	ABERCROMBIE,L ** PRINCIPLES OF LITERARY CRITICISM ** 160P 18 ZZ
PC6001.A14R7 1926	ABERCROMBIE,L ** ROMANTICISM ** ZZ ZZ ZZ
PC6001.A14S2 1931	ABERCROMBIE,L ** THE SALE OF SAINT THOMAS ** 124P 19 ZZ
PC6001.A14T3 1926	ABERCROMBIE,L ** THE THEORY OF POETRY ** ZZ ZZ ZZ
BD 161.A14 1960	ABERCROMBIE,ML ** THE ANATOMY OF JUDGMENT ** 156P 22 ZZ
BX4721.A14 1936	ABERCROMBIE,N ** THE ORIGINS OF JANSENISM ** 341P 23 ZZ
D 15.B57A2 1959	ABERCROMBIE,N ** THE LIFE AND WORK OF EDMUND BISHOP ** 539P 22 ZZ
CS 71.A15A14	ABERCROMBIE,RT ** THE ABERCROMBIES OF BALTIMORE ** ZZ 23 2
QC 981.A14	ABERCROMBY,R ** WEATHER ** ZZ ZZ ZZ
QC 992.A7A2 1896	ABERCROMBY,R ** THREE ESSAYS ON AUSTRALIAN .WEATHER ** 101P 22 ZZ
QC 995.A15	ABERCROMBY,R ** PRINCIPLES OF FORECASTING BY MEANS OF WEATHER CHARTS ** 123P 24 ZZ
F 1033.A25 1960	ABERDEEN AND TEMAIR,IM ** THE CANADIAN JOURNAL OF LADY ABERDEEN ** 517P 25 ZZ
LF 968.A2	ABERDEEN UNIVERSITY ** ROLL OF ALUMNI IN ARTS OF THE UNIVERSITY AND KING S COLLEGE OF ABERDEEN ** 17 5P ZZ ZZ
D 639.E53A3	ABERDEEN. UNIVERSITY ** ROLL OF SERVICE IN THE GREAT WAR ** 441P 26 ZZ
LF 968.A2 1900	ABERDEEN. UNIVERSITY ** ROLL OF THE GRADUATES OF THE UNIVERSITY OF ABERDEEN ** 687P 25 ZZ
LF 968.A2 1935	ABERDEEN. UNIVERSITY ** ROLL OF THE GRADUATES OF THE UNIVERSITY OF ABERDEEN ** 952P 26 ZZ
LF 969.B6A2	ABERDEEN. UNIVERSITY ** QUATERCENTENARY OF THE DEATH OF HECTOR BOECE ** 53P 2 ZZ
LF 977.A3	ABERDEEN. UNIVERSITY ** RECTORIAL ADDRESSES DELIVERED IN THE UNIVERSITY OF ABERDEEN ** 336P 21 ZZ
GN 37.A2A14	ABERDEEN. UNIVERSITY. ANTHROPOLOGICAL MUSEUM ** ILLUSTRATED CATALOGUE OF THE ANTHROPOLOGICAL MUSEU ** 357P 21 ZZ
PC3331.A14A2	ABERDEEN. UNIVERSITY. LIBRARY ** CATALOGUE OF GREEK AND LATIN PAPYRI AND OSTRACA IN THE POSSESSION OF THE UNIVERSITY OF ABERDEEN ** 116P 26 ZZ
PE 6.A14	ABERDEEN. UNIVERSITY. LIBRARY ** CATALOGUE OF THE BOOKS IN THE CELTIC DEPARTMENT ** 69P 24 2
PQ2199.B5P97	ABERDEEN. UNIVERSITY. LIBRARY ** CATALOGUE OF THE TAYLOR COLLECTION OF PSALM VERSIONS ** 307P 22 ZZ
Z 921.A14P	ABERDEEN. UNIVERSITY. LIBRARY ** CATALOGUE OF PAMPHLETS IN THE KING ** ZZ ZZ ZZ
DA 22.A14 1949	ABERDEEN. UNIVERSITY. LIBRARY ** MACBEAN COLLECTION ** 307P 25 ZZ
Z 921.A14	ABERDEEN. UNIVERSITY. LIBRARY. MARISCHAL COLLEGE ** CATALOGUE OF THE BOOKS ADDED TO THE LIBRARY IN MA RISCHAL COLLEGE 1874-1896 ** ZZ ZZ ZZ
Z 921.A14M 1921	ABERDEEN. UNIVERSITY. LIBRARY. CRUICKSHANK SCIENCE LIBRARY ** CRUICKSHANK SCIENCE LIBRARY ** 337P 21 ZZ
LF 978.1906.	ABERDEEN, UNIVERSITY ** RECORD O[illegible] CELEBRATION OF THE QUATERCENTENARY OF THE UNIVERSITY OF ABERDEE N ** 656P 26X20 ZZ

Fig. 13

due in part to the sheer size of the file, in part to the fact that the transcribing was necessarily done by people without library training; and partly also, because there was no prior experience in planning such a task, and attention had to be concentrated on basic matter. In the planning of input records for new cataloging, all of these constraining factors are removed; and in addition the record form for SLOT was carefully designed to provide for compatibility, in processing and merging, with an expanded record format. The result is much greater latitude in planning the elements of information to be abstracted; and the Library administration has been quick to take advantage of this. Current input record processing includes, for example, such additional information as the sub-title of the work, if there is one, and a "series" statement wherever this is indicated. That such expansion has led to expanded chores in finding an accommodation between the subtleties of library entry and ordering and the operating habits of computers is only to be expected. The staff has continued to tackle these chores with good cheer and vigor, and experience is continually being gained.

ACQUISITIONS AND CATALOGING

Mention has been made above (pp. 4-5) of the dissertation of Satinder K. Mullick resulting in the formulation of decision rules for expanding or contracting staff in Acquisitions and Cataloging according to the magnitude and time lag of the in-process inventory.

At the time Mullick carried out this part of the project the back-log was substantial in both the number of books awaiting processing and the length of attendant delays.

By and large, these conditions still prevail but the most awkward consequences of them have been ameliorated by adoption of a new procedure. Previously a book which had been acquired but not yet cataloged remained virtually inaccessible to patrons until cataloged and shelved; now, as books are received, temporary catalog cards are prepared and filed by main entry in the public catalog. These cards do not carry bibliographic information but they do permit patrons more easily to charge out such items as may be wanted. To differentiate them from regular catalog cards the temporary cards are color coded.

A patron who wishes to charge out such an item must first ascertain its presence and in-process location by observation of the temporary card. He must then inquire at the Circulation Desk to set in motion the prompt cataloging of the book in order that it may be processed in the usual way. Since the number of such items is not large, this procedure has worked well but it does of course require extra filing and refiling of catalog cards and occasional special handling in the manner just described. Because of this, and for the added reason that large back-log does not appear necessary for work-load stability, those on the project team are still inclined to feel that Mullick's decision rules should be vigorously implemented. It is, as the saying goes, just as easy to walk beside a person as twenty steps behind.

ACTIVITIES OF THE LIBRARY STAFF

One of the major oversights in the implementation of the circulation control system has been our persistent tendency to analyze and describe the system in terms of hardware, software and technique, with insufficient attention to the personnel and organizational subsystems. What has been

too often overlooked is the complex of jobs and tasks of the people who make the system work. In any work situation one expects new job and task structures to develop alongside of new tools and techniques. Furthermore, since jobs are defined around functions, and not the other way round, one expects that innovations and accommodations in the personnel subsystem will lag behind the delivery of the new piece of hardware or the adoption of the new procedure. This means that it takes a while to rationalize job structures and task assignments in ways that are feasible for recruitment, training, performance and communications on the job. It means that for a while after a system changeover there will be a number of non-rationalized job structures and task assignments. That is, some people will not know what they should do, some people will not know how to do what they are supposed to do, and the same people may very likely be trying to do too much or too little, of tasks that are too hard or too easy, in ways that are too fast or too slow.

In the past year, a great deal of thought and planning have gone into a concerted attempt by the library staff to better rationalize the personnel subsystem. Specific changes and improvements which have been made are the following:

1. Physical move of the keypunch operation and reorganization of that work space.
2. Reorganization of the work space at the Circulation Desk.
3. Job descriptions have been prepared for all positions.
4. Training manuals are close to completion for jobs in the keypunch area and at the Circulation Desk.
5. New staff positions have been added at both the supervisory and operational levels.

6. The three middle-level supervisory positions have all been filled by new and better qualified persons.
7. Training of supervisory personnel has been initiated with courses in computer programming, and visits to see computer-based circulation control systems in other university libraries.
8. More responsibility has been delegated to the operations personnel for technical operations and planning. Most computer runs can now be performed by the library staff, some new computer programs have been written, and other procedural changes in photographic and computer processing have been designed and implemented.
9. The library supervisory staff now has improved communications with the staff of the university computing center and with other computer users in the administrative area. These associations hopefully are leading to the formation of an administrative computer users' group on campus. This will have implications for sharing of data files, standardization of data formats, reduction in data conversions, etc.

It should be noted that the library administration has been responsible for and committed to the analysis, planning, and execution of each of these changes. While the library staff takes some pride and satisfaction in these accomplishments, they are in no sense sufficient in terms of overall library needs and objectives. Clearly, more library staff members must become increasingly involved and technically knowledgeable in the operation of the circulation system, and in the application of computer techniques to library operations. There are specific jobs, roles and responsibilities in the circulation system and in related areas that now need better definition and rationalization.

In the development of this capability of specialized, technical expertise within the library staff, it behooves us to take a hard look at the experience of our colleagues at other universities.

For this sort of technological innovations in university libraries, there have been basically three forms of funding and administrative control that have been adopted.

1. The most common approach is to form a small project team composed of library and computing center staff. Staff costs for analysts and programmers are borne by the computing center on a service basis, and all other costs of design and implementation are carried by the library. The University of Michigan, State University of New York and Lehigh are examples of this approach.
2. Another approach is to develop a computer systems and programming department within the library, and to fund the costs of system development, from the library budget, sometimes with help from foundation grants. The University of Missouri has taken this approach relying entirely on local funds; Columbia and the University of Chicago have sought and received foundation funds for projects coordinated by the University librarian.
3. Another common approach for bringing specialized, technical expertise to bear on particular library problems has been the use of consultants and researchers on a short term basis. Both the Purdue and M.I.T. libraries have called in operations research workers for in-depth, analytical, study of selected problems. These studies were often connected with advanced academic degree programs, and were so structured that the research workers were not held responsible for operational decisions and problems arising in the implementation of study findings.

If there is any relevance in these administrative/funding models to the pursuit of technological innovation in the Hopkins Library, then it may be argued that it is desirable to distinguish between research and operations functions, and to maintain library administrative control over all projects and designs having a direct bearing on daily library operations.

If we consider the library within the microcosm of the Homewood campus, it is clear that like the Registrar, the Controller, Alumni Records, and others, it has total reliance on several basic record handling systems. Each of these offices, the library included, is now committed to the development of computer record processing systems and supporting staff. It is possible that as more is learned and communicated about the intricacies of these systems, more sharing and economies through cost distribution may be realized. But each office must of necessity maintain administrative flexibility and control over changes in the structure, format and access to its basic files.

SUMMARY

This Report has recounted the work of the past three years, most of which have been devoted to necessary implementation of the new system of circulation control. Out of this work ideas for a much better system have been proposed by Benjamin F. Courtright, Jr., who has been principal architect for the method now in successful operation. His new plan proposes adoption and use of seven-digit, self-checking code numbers, along with optical scanning, a technique which promises to retain the advantages of the present system, while avoiding the weaknesses which have proved troublesome in the past. The achievement of on-line, real-time capability appears feasible under the new system proposed.

Other parts of this narrative have recounted progress made and work yet to be done on the shelf list on tape and in Acquisitions and Cataloging. These projects, and especially the proposed new system of circulation control, will, we hope, be carried to successful conclusions.

SECTION III

NEW DEVELOPMENTS

NEW DEVELOPMENTS

Because of operational problems of the sort cited in the preceding sections, and because, also, of new possibilities opened up by very recent advances in relevant technologies, plans have been devised for new and improved procedures in circulation control. These plans have evolved into an orderly progression of phases, or stages of new development. They begin with a radical alteration of the input identifier for a library item involved in a circulation transaction.

As is clear from the recapitulation at the beginning of this section of the report, the input identifier for an item has been, from the beginning, the call number. The call number was chosen because it should be readily accessible on every cataloged item, and because of the high degree of redundancy it contains, making the inadvertant transposition of one call number into another actual call number in the Library's set a very unlikely event. For reasons adequately documented above, however, the call number has proved to be less than optimal. The variation in format and legibility of the call number labels, their length, complexity and alphanumeric nature are some of the readily identifiable contributing factors to this situation. The proposal is therefore made that this traditional bibliographic code be supplemented (not replaced) by a simpler, more rational identifier to be used as input for transactions affecting an item. It is proposed that this identifier be a simple all-numeric code -- specifically, the set of sequential numbers large enough for the collection -- augmented by one or more digits added to provide an integral error-detection capability.

In the case of the Eisenhower Library, the set of six-digit numbers is large enough to comprise all items in the collection which might

conceivably circulate in the foreseeable future. For the additional error-detecting element, it was found that one additional digit, developed by a suitably sophisticated algorithm, is sufficient to confer remarkable error-detection capabilities. Specifically, use of a seventh digit developed by this algorithm for automatic detection of errors in transcription, when the input element is processed through the computer, provides the ability to

(1) detect <u>any</u> error made in transcription of a single digit;

(2) detect all errors which consist of transpositions of any two digits, whether adjacent or not;

(3) provide a variable but high probability of detecting more complex errors, which are more remotely likely to occur.

In order to make a system utilizing such a rational set of identifying code numbers operable, at the same time retaining all capabilities of the present system, with reference by call numbers possible, provision must be made to associate a code number, in some readily accessible manner, with each volume which is involved in a circulation transaction; and the code number and the call number of the item must be associated in an appropriate machine-readable file.

The first of these requirements may be achieved in the following manner: Labels on durable stock, just large enough to carry the imprint of the seven-digit redundant code number in large, legible characters are prepared (Fig. 14). Rolls of such labels may be put in automatic dispensers situated on the circulation counter immediately adjacent to the charge-out area. When a book is circulated for the first time under the new system, one of the small code number labels is taken from the dispenser and put on the book immediately above the call number label on the spine. The book is then recorded photographically on microfilm for charge-out. When the

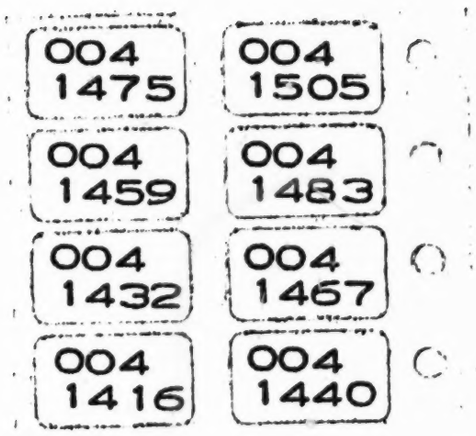

Fig. 14 Code number labels, from test run

film is converted on the key-punch, for this item being charged out for the first time, both the code number and the call number of the item are punched in the transaction card. When the resulting record is processed on the computer, the call number is entered into the circulation tape file as before; but in addition both the call number and the code number are entered in a special machine-readable file comprising a table of code numbers and their associated call numbers - a file which has come to be known in the planning activity as the "Dictionary File".

When this item is returned, and for all subsequent charge and discharge transactions affecting it, only the code number is key-punched on the transaction card. In subsequent processing of an item of this sort on the computer the call number of the item is retrieved from the Dictionary File, where it had previously been stored associated with the code number. This is the heart of the processing system. All other processing activities affecting the circulation file are carried out on the computer in the same manner as in the present system.

In future extensions of the system, it is proposed that the code number labels be imprinted in a machine-readable format; and that the code numbers be read directly into the computer by a suitable small optical scanner situated on the circulation counter. Realistic estimates for the development of such a device have been obtained. Given a suitable direct access, on-line computer capability in the operating environment this will confer the ability to conduct inquiry-and-response operations concerning the circulation file on an up-to-date real-time basis.

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